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Facts & Figures

of the

U.S. Plastics Industry

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THE SOCIETY OF THE PLASTICS INDUSTRY, INC.

The Society of the Plastics Industry, Inc. is a member-run association dedicated to promoting and protecting continuing growth for the plastics industry in the United States. The Society represents more than 2,000 member companies.

Incorporated in 1937, SPI has grown with the dynamic industry it represents. SPI's 27 operating units and more than 200 committees have membership drawn from all segments of the industry - processors, resin and adjuvant suppliers, plastics distributors, machinery builders, and moldmakers. The Society serves as a federation of semi-autonomous, interrelated groups with a strong, common interest in the overall health of the plastics industry.

SPI serves as the "industry spokesman." It identifies and provides positive responses to misinformation and to potentially harmful regulations, bills, or court decisions by mobilizing pertinent facts and carrying out programs for timely and forceful action. At the same time, SPI works to prevent such damaging situations from occuring by building a positive understanding of the industry. The Society's service committees provide liaison with government agencies, code and regulatory groups, and many other associations.

SPI sponsors research projects in areas such as resource recovery, combustibility, and worker safety, at major private research organizations. The Society conducts numerous information programs, providing literature, surveys, reports, newsletters, and handbooks for industry and public use.

SPI sponsors one of the largest trade shows in the United States - the National Plastics Exposition, held every three years. The most recent show was held in June 1988 at McCormick Place in Chicago.

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SPI'S COMMITTEE ON RESIN STATISTICS

The SPI Committee on Resin Statistics is composed of 100 representatives from plastics resin producing companies, trade publications, industry-related professional organizations, and various agencies of the Federal Government. All members of the Committee are quite knowledgeable of the rapidly growing plastics industry and have a special interest in the development of marketing and economic data.

The Committee is responsible for the development and maintenance of a monthly report on the major plastics materials. This report shows monthly and cumulative data on production and sales & use (including captive operations) with percent change from the previous year. It is the only detailed monthly report on plastics materials now available. There are over one hundred producers participating in the monthly program and they are believed to represent about 95% of total U.S. plastics production. Many of the materials covered reflect 100% industry coverage. The data is compiled by Ernst & Whinney*, nationally renowned Independent Public Accountants.

The Committee is actively involved with the various departments of the Federal Government (International Trade Commission, Department of Commerce, Bureau of the Census, Bureau of Labor Statistics, etc.) assisting them in the development and improvement of the plastics segments of their reports.

The Committee is also responsible for monitoring all resin data which appear in FACTS & FIGURES, thus assuring the most accurate and timely data.

* Became Ernst & Young in July, 1989.

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General Statistics

DEVELOPMENT OF TODAY'S PLASTICS

Today's plastics are one of the most used materials on a volume basis in America's industrial and commercial life. The role of plastics is so broadly integrated in our own lifestyle that today there is virtually no product area where plastics do not make a major, irreplaceable contribution. Although the plastics industry in the United States is now in its second century, the most important developments have occurred since 1910. However, the roots of these modern develpoments go back not only to the research of cellulose nitrate by John Wesley Hyatt in the 1860's, but also to the plastic-like compositions used by man through the centuries.

ORIGIN OF PLASTICS

One can go as far back as the Old Testament to find references about natural materials used as fillers, adhesives, coatings, and the like. These materials were the precursors of what we call plastic materials today. Consequently, historians differ as to the exact date that the plastics industry began, and they will continue to do so since an exact year or even decade for the event is a matter of interpretation as to what constitutes a "plastic."

Certainly the history of the rubber industry has a bearing on plastics since ebonite, or hard rubber, discovered in 1851, was the first thermosetting material to be prepared and also the first material which involved a distinct chemical modification of a natural material. But ebonite was not exploited commercially for some years after its discovery and for that reason its historical importance has become somewhat blurred.

EUROPEAN DEVELOPMENTS

While the basic processes of rubber technology were developing, other important discoveries were taking place in Europe. Following work by Pelouze, Schonbein was able to establish conditions of controlled nitration of cellulose. The product soon became of interest as an explosive and in the manufacture of collodion, a cellulose solution in an alcohol-ether mixture. In the 1850's the English inventor Alexander Parkes observed that the solid residue left after the evaporation of the solvent of photographic collodion was a "hard, horny elastic and waterproof substance." In 1856 he patented the process of waterproofing woven fabrics by the use of such materials.

In 1862 the Great Exhibition was held in London. It was there that Parkes introduced a new material named for himself--Parkesine. Parkesine was obtained by dissolving cellulose nitrate in a minimum of solvent. The mixture was then put on a heated rolling machine from which some of the solvent was then removed. While still in the plastic state the material was then shaped by dies or pressure. In 1866 Parkes organized the Parkesine Company to manufacture products from his new material, but the company failed in 1868. This appears in part due to Parkes' attempt to reduce production costs which resulted in the production of inferior items.

One year after the failure of the Parkesine Company, an associate of Parkes, Daniel Spill, formed the Xylonite Company to manufacture products similar to Parkesine. Once again, economic failure resulted and Spill's company went bankrupt in 1874. Undaunted, Spill moved to a new site, established the Daniel Spill Company and continued production of his material, Xylonite.

FIRST PLASTICS IN THE U.S.

In the United States during the 1860's, someone else was experimenting with cellulose nitrate--John Wesley Hyatt. In 1865, Hyatt became involved in devising a method for producing billiard balls from materials other than Ivory. Originally using mixtures of cloth, ivory dust and shellac, in 1869 he patented the use of collodion for coating billiard balls. The patent came one year after his collodion material was introduced commerically.

John W. Hyatt and his brother Isaiah took out U.S. Patent 105,338 in 1870 for a process of producing a horn-like material using cellulose nitrate and camphor. Although Parkes and Spill had mentioned camphor in their work, it was the Hyatt brothers who recognized the value of camphor as a plasticizer for cellulose nitrate. In 1872, the term celluloid was coined by Isaiah Hyatt to describe the Hyatts' commerically successful product.

The validity of Hyatts' patents was challenged by Spill and a number of court actions took place between 1877 and 1884. In the final action, it was found that Spill had no claim on the Hyatt brothers, the judge ruling that the true inventor of the process was Parkes since he (Parkes) had mentioned the use of camphor in his patents. Thus, there was no restriction on the use of these processes and any company, including the Hyatts' Celluloid Manufacturing Company, was free to use them. After that decision, the Celluloid Manufacturing Company prospered, changed its name to the American Cellulose Chemical Corporation, and eventually was absorbed by the Celanese Corporation.

FORMALDEHYDE RESINS

Next to cellulose nitrate, the most important material in the early history of plastics was formaldehyde. Around 1897 there was a demand in German schools for a white chalkboard. Efforts to obtain such a product resulted in the discovery of casein plastics, produced by reacting casein (milk protein) with formaldehyde. The material soon became established under the trade names of Galalith and Erinoid, and today casein is still used by the button industry.

In 1899, Arthur Smith took out British Patent 16,275, the first dealing with phenol-formaldehyde resins, in this case for use as an ebonite substitute in electrical insulation. During the next decade, the phenol-formaldehyde reaction was investigated mainly for academic interest. In 1907, however, Leo Hendrik Baekeland discovered techniques of so controlling and modifying the reaction that useful products could be made from it. Thus phenolics were the first fully synthetic resins to become commerically successful.

Prompted by the success of phenolic moldings, research began on reacting other materials, such as urea and thiourea, with formaldehyde. These materials were used in the manufacture of molding powders. Unlike phenolics, they could be molded into light-colored articles and they rapidly achieved commerical success. Today these urea-based resins are used for molding powders, adhesives, and textile and paper finishing while the related melamine-formaldehyde resins are used in decorative laminates.

GROWTH OF MODERN PLASTICS

Cellulose acetate, a thermoplastic, was developed about the same time as the urea-based resins. Similar in structure to cellulose nitrate, it was found to be safer in processing and use. Cellulose acetate was introduced as a molding compound in 1927.

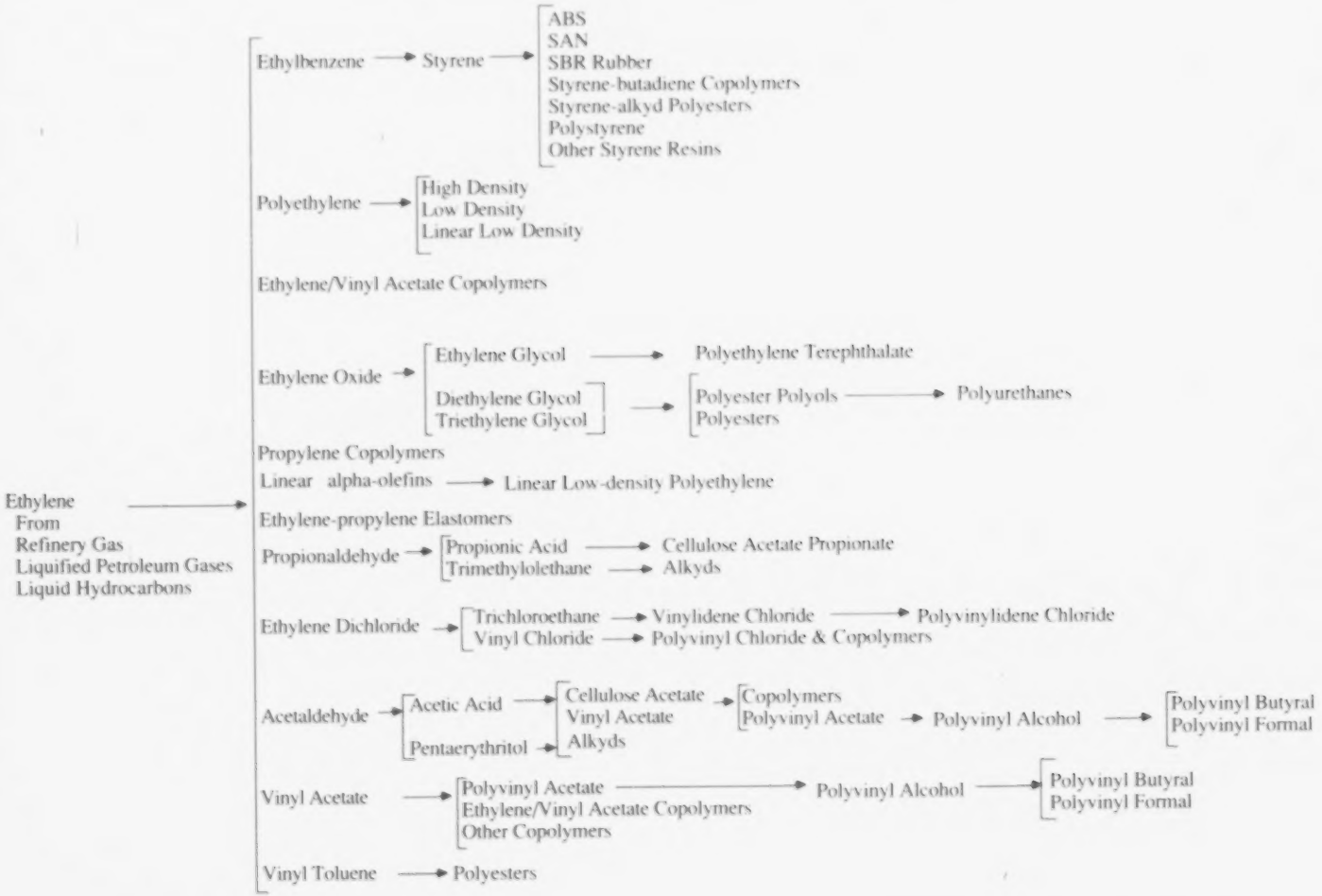
The period 1930-1940 saw the initial commercial development of today's major thermoplastics: polyvinyl chloride, low density polyethylene, polystyrene, and polymethyl methacrylate. The advent of the Second World War in 1939 brought plastics into great demand, largely as substitutes for materials in short supply, such as natural rubber. In the United States, the crash program leading to large-scale production of synthetic rubbers resulted in extensive research into the chemistry of polymer formation, and eventually, to the development of more plastic materials.

The first decade after World War II saw the development of high density polyethylene and polypropylene and the growth of the new plastics in many applications. Large-scale production of these materials reduced their cost dramatically. The new materials began to compete with the older plastics and even with the more traditional materials such as wood, paper, metal, glass and leather. Since that time, the demand for plastics has increased steadily so that plastics are now accepted by designers and engineers as basic materials along with the more traditional materials. The automotive industry, for instance, relies on plastics to reduce weight and thus increase mileage.

INTRODUCTION OF PLASTIC RESINS

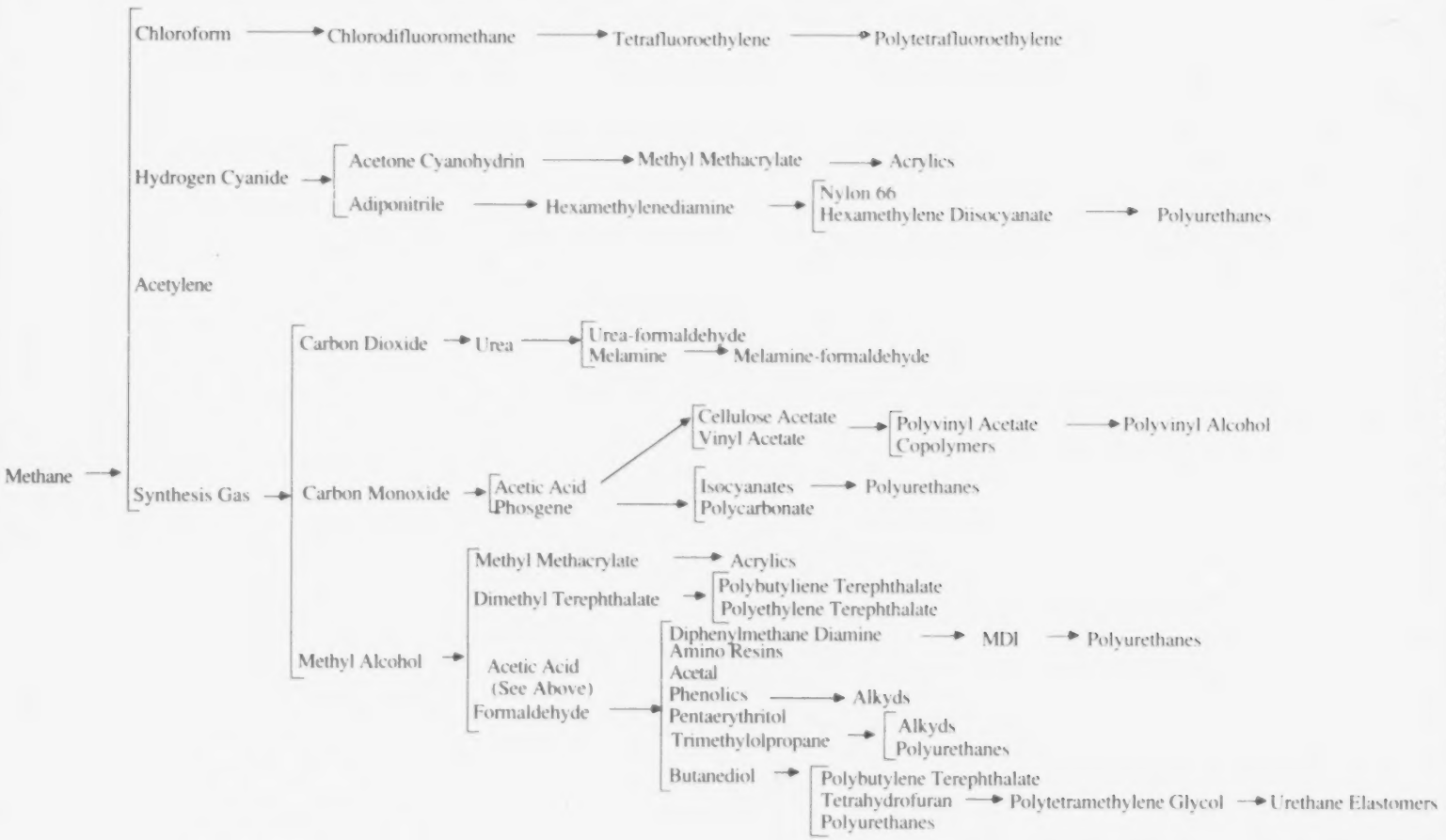
DATE	MATERIAL	EXAMPLE
1868	Cellulose Nitrate	Eye Glass Frames
1909	Phenol-Formaldehyde	Telephone Handset
1919	Casein	Knitting Needles
1926	Alkyd	Electrical Bases
1927	Cellulose Acetate	Tooth Brushes
1927	Polyvinyl Chloride	Wall Covering
1929	Urea-Formaldehyde	Lighting Fixtures
1935	Ethyl Cellulose	Flashlight Cases
1936	Acrylic	Brush Backs
1936	Polyvinyl Acetate	Flash Bulb Lining
1938	Cellulose Acetate Butyrate	Packaging
1938	Polystyrene	Housewares
1939	Nylon	Gears
1939	Polyvinylidene Chloride	Packaging Film
1939	Melamine-Formaldehyde	Tableware
1942	Unsaturated Polyester	Boat Hulls
1942	Low Density Polyethylene	Packaging
1943	Fluoropolymers	Industrial Gaskets
1943	Silicone	Motor Insulation
1945	Cellulose Propionate	Pens and Pencils
1947	Epoxy	Tools and Jigs
1948	Acrylonitrile-Butadiene-Styrene (ABS)	Luggage
1954	Styrene-Acrylonitrile (SAN)	Housewares
1954	Polyurethane	Foam Cushions
1956	Acetal	Automotive Parts
1957	High Density Polyethylene	Milk Bottles
1957	Polypropylene	Safety Helmets
1957	Polycarbonate	Appliance Parts
1959	Chlorinated Polyether	Valves and Fittings
1962	Phenoxy	Bottles
1964	Ionomer	Skin Packaging
1964	Polyphenylene Oxide	Battery Cases
1964	Polyimide	Bearings
1964	Ethylene-Vinyl Acetate	Adhesives and Coatings
1965	Polysulfone	Electrical/Electronic Parts
1970	Thermoplastic Polyester	Electrical/Electronic Parts
1973	Polybutylene	Piping
1973	Polyphenylene Sulfide	Telecommunications
1974	Polyethersulfone	Printed Circuit Boards
1975	Nitrile Barrier Resins	Non-food Packaging
1978	Linear Low Density Polyethylene	Extruded Film
1982	Polyetherimide	Electrical/Electronic Parts
1983	Polyetheretherketone	Wire and Cable
1984	Aromatic Copolyester	Electrical/Electronic Parts
1985	Liquid Crystal Polymers	Electrical/Electronic Parts

Plastics Derived From Ethylene



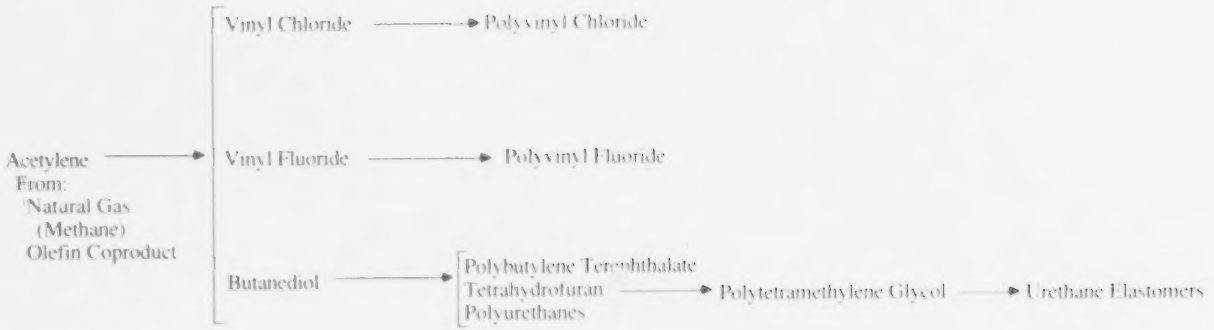
Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Methane



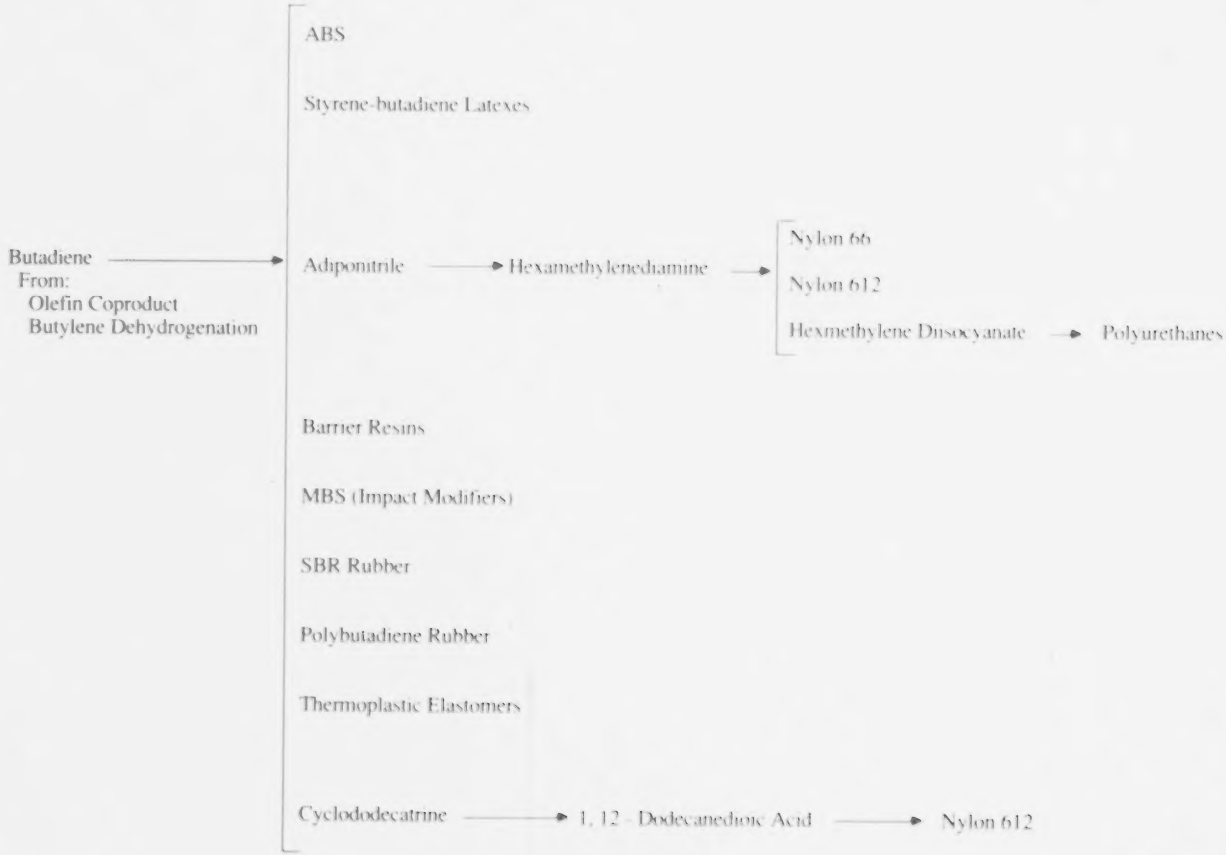
Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Acetylene



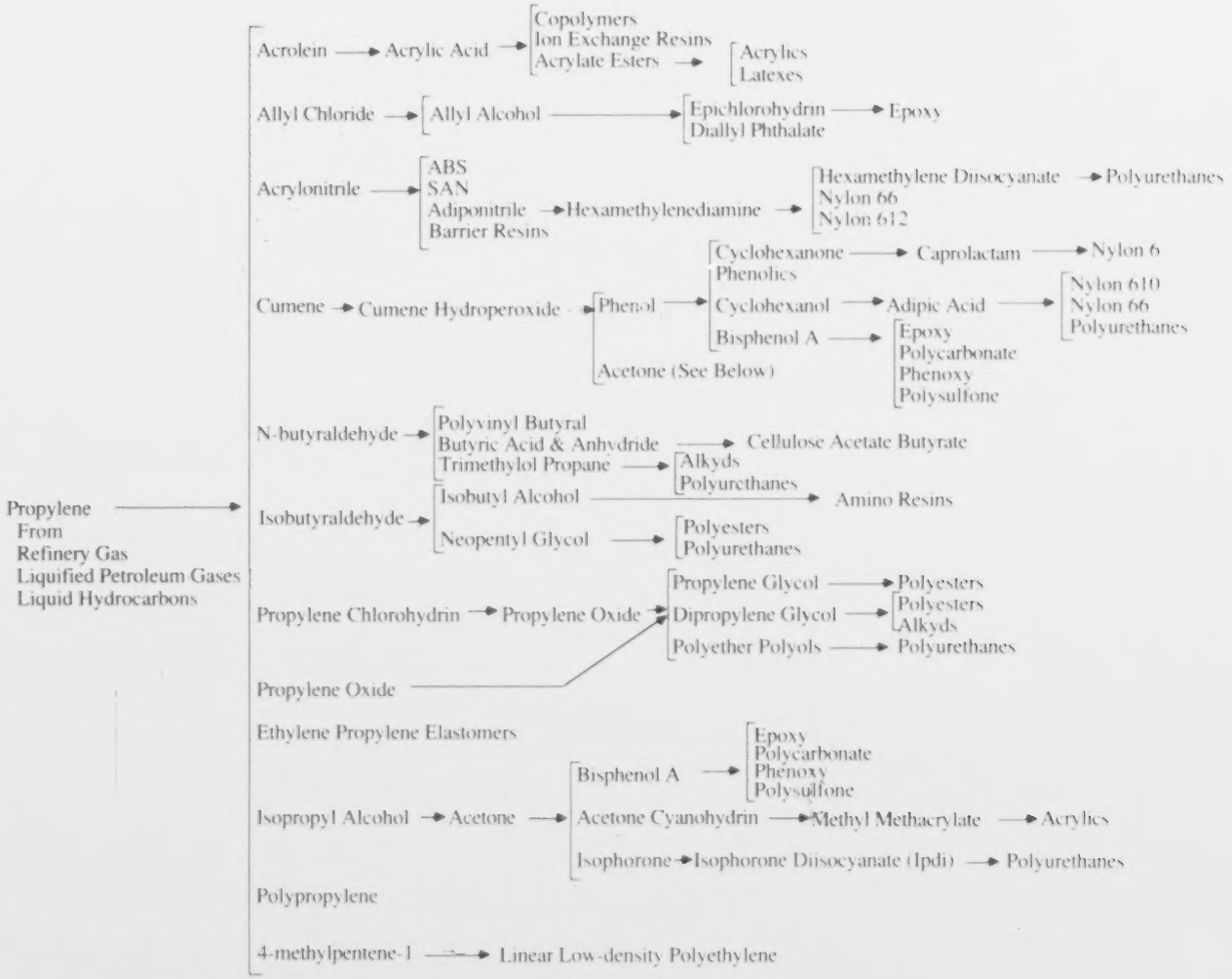
Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Butadiene



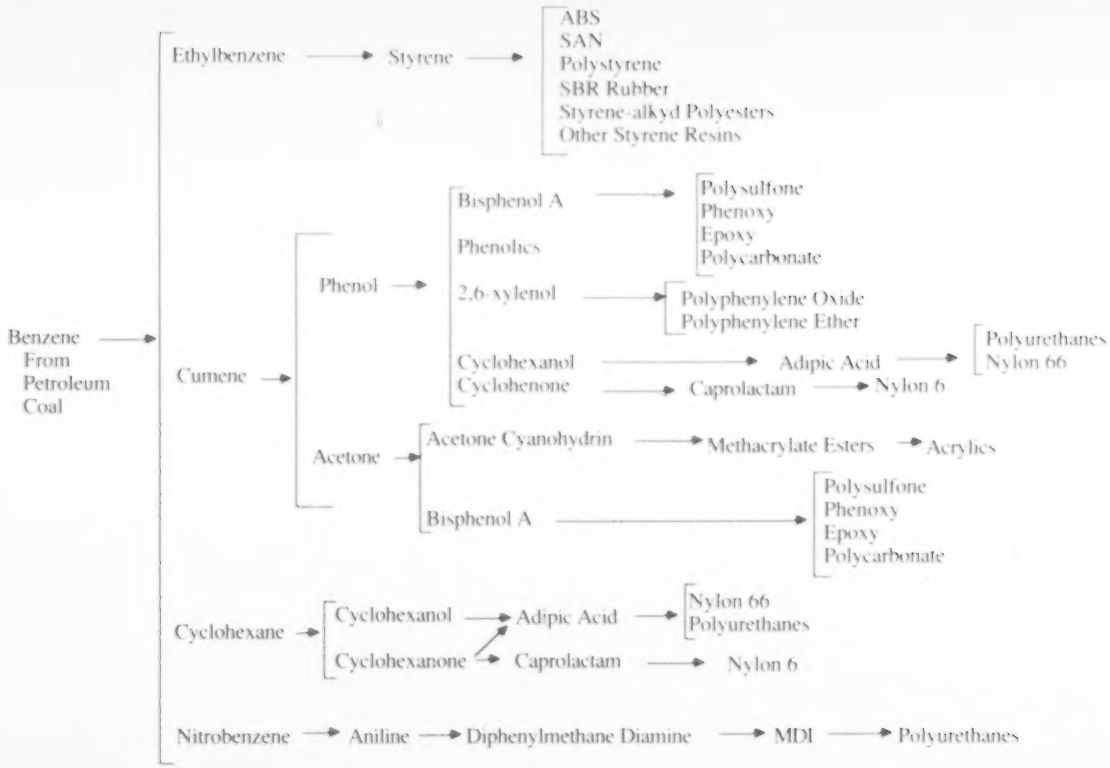
Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Propylene



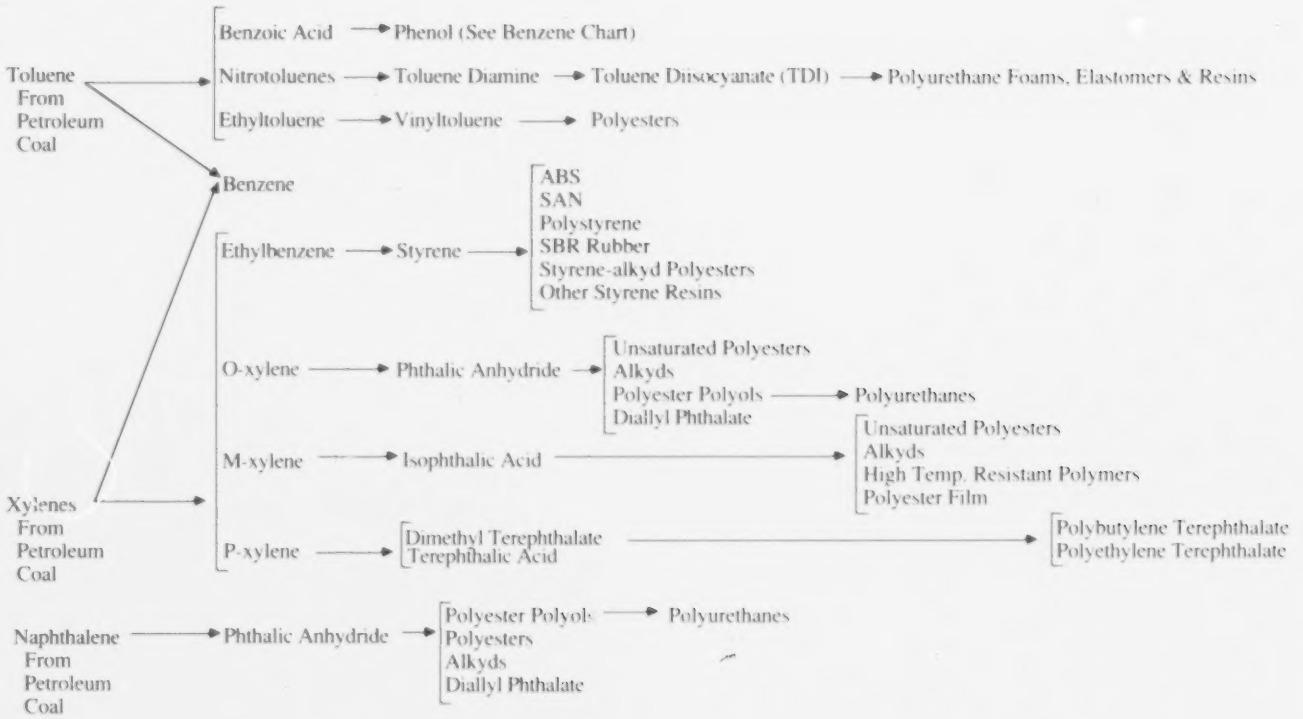
Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Benzene



Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Naphthalene, Toluene & Xylenes



Source: Extracted in part from SRI International, Chemical Origins & Markets

PLASTIC MATERIALS & RESINS

VALUE OF SHIPMENTS

(in millions of dollars)

VERSUS LARGEST CHEMICAL CATEGORIES	1985	1986	1987[1]	1988[2]	COMPOUND GROWTH RATE 1985-1988
Industrial Organic Chemicals	41,271	36,773	39,470	44,830	3.0%
Drugs	31,332	34,418	37,794	41,268	9.7
Soaps, Cleaners & Toilet Goods	29,555	31,386	32,989	35,436	6.2
Plastic Materials & Resins	**20,262**	**21,484**	**26,122**	**32,498**	**17.0**
Industrial Inorganic Chemicals	18,183	17,298	17,162	17,704	-2.0
Paints and Allied Products	11,562	11,725	11,140	11,850	0.9
Fertilizers	7,654	5,574	6,683	8,101	2.0

VERSUS OTHER COMMODITIES	1985	1986	1987[1]	1988[2]	COMPOUND GROWTH RATE 1985-1988
Steel Mill Products	47,354	44,119	49,055	55,480	5.3%
Paper and Board	35,923	37,177	41,175	46,460	8.8
Plastic Materials & Resins	**20,262**	**21,484**	**26,122**	**32,498**	**17.0**
Primary Aluminum	4,488	4,355	4,849	4,121	3.7
Synthetic Rubber	2,841	2,740	2,915	2,940	1.0
Primary Copper	2,239	2,247	2,805	3,100	11.3
Leather Tanning & Finishing	1,643	1,589	1,862	2,188	10.0

1. Estimated Except for Exports and Imports
2. Estimated

Source: Department of Commerce

PLASTIC MATERIALS & RESINS

(SIC 2821)

(in millions of dollars except as noted)

	1985	1986	1987[1]	1988[2]	PERCENT CHANGE 1985-86	1986-87	1987-88
Industry Data							
Value of shipments[4]	20,262	21,484	26,122	32,498	6.0	21.6	24.4
Value of shipments (1982$)[3]	19,045	20,650	23,769	25,076	8.4	15.1	5.5
Total employment (000)	55.4	54.7	55.0	55.0	-1.3	0.5	0.0
Production workers (000)	34.4	34.1	34.7	34.7	-0.1	1.8	0.0
Average hourly earnings ($)	14.33	15.06	15.90	16.20	5.1	5.6	1.9
Product Data							
Value of shipments[5]	21,574	22,905	27,818	34,985	6.2	21.4	25.8
Value of shipments (1982$)[3]	20,122	21,837	24,971	26,344	8.5	14.4	5.5
Shipments price index (1982 = 100)[6]	107.2	-	-	-	-	-	-
Trade Data							
Value of imports (ITA)[7]	772	872	-	-	13.0	-	-
Import/new supply ratio[8]	0.032	.035	-	-	9.4	-	-
Value of exports	2,547	2,805	3,688	3,800	10.1	31.5	3.0
Export/shipment ratio	0.114	.122	0.143	0.117	7.0	17.5	-18.2

MISCELLANEOUS PLASTIC PRODUCTS

(SIC 3079)

(in millions of dollars except as noted)

	1985	1986	1987[1]	1988[2]	PERCENT CHANGE 1985-86	1986-87	1987-88
Industry Data							
Value of shipments[4]	49,761	52,243	54,298	60,206	5.0	3.9	10.9
Value of shipments (1982$)[3]	47,548	48,881	50,239	52,751	2.8	2.8	5.0
Total employment (000)	541	547	595	-	1.1	8.8	-
Production workers (000)	424	424	469	-	0.0	10.6	-
Average hourly earnings ($)	7.81	8.10	8.26	-	3.7	2.0	-
Product Data							
Value of shipments[5]	49,963	52,518	56,127	6,234	5.1	6.9	10.9
Value of shipments (1982$)[3]	47,741	49,139	51,931	54,528	2.9	5.7	5.0
Shipments price index (1982 = 100)[6]	1,047	-	-	-	-	-	-
Trade Data							
Value of imports (ITA)[7]	2,100	3,209	3,816	-	52.8	18.9	-
Value of exports[8]	2,000	2,155	2,634	-	7.8	22.2	-

[1]Estimated except for exports and imports
[2]Estimated
[3]Forecast not included in this reproduction
[4]Value of all products and services sold
[5]Value of products classified in the industry produced by all industries
[6]Developed by the Office of Industry Assessment, ITA
[7]Import data are developed by the chapter author of the source
[8]Export data are developed by the chapter author of the source
SOURCE: U.S. Department of Commerce: Bureau of the Census, Bureau of Economic Analysis, International Trade Administration (ITA). Estimates and forecasts by ITA.

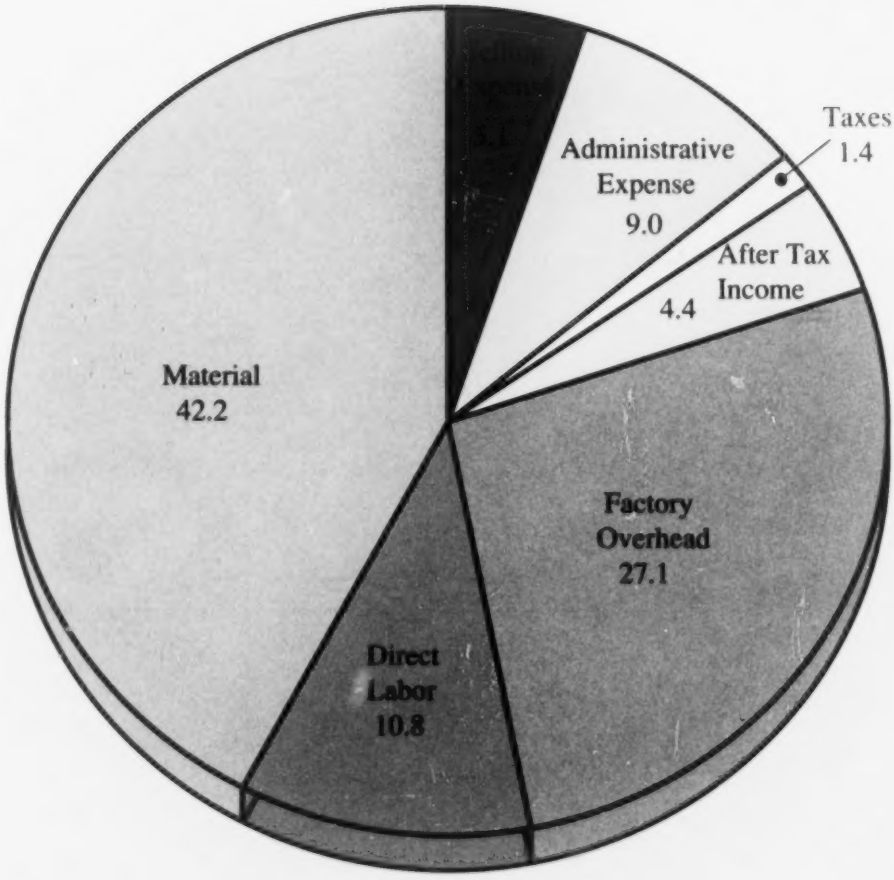
PROFILE OF 25 LARGEST MANUFACTURING INDUSTRIES

RELATIVE 1988 RANK	SIC	INDUSTRY	1988 INDUSTRY SHIPMENTS (MIL. 1982$)
1	2911	Petroleum refining	$ 207,960
2	3573	Electronic Computing Equipment	139,902
3	3711	Motor vehicles & car bodies	116,209
4	**3079**	**Miscellaneous plastic products •**	**64,474**
5	3714	Motor vehicle parts & accessories	64,460
6	3662	Radio & TV communication equipment	48,648
7	2011	Meat packing plants	44,555
8	3674	Semiconductors & related devices	42,873
9	331A	Steel mill products	39,862
10	2869	Industrial organic chemicals	39,149
11	275A	Commerical printing & lithographic	36,660
12	3721	Aircraft	34,420
13	2621	Paper mills, except building paper	25,625
14	2711	Newspaper	22,945
15	**2821**	**Plastic materials & resins**	**20,918**
16	2834	Pharmaceutical preparations	20,500
17	2026	Fluid milk	20,345
18	2086	Soft drinks	20,200
19	3661	Telephone & telegraph apparatus	19,800
20	3761	Guided missiles & space vehicles	19,700
21	3861	Photographic equipment & supplies	17,400
22	3679	Electronic Components n.e.c.	16,567
23	3724	Aircraft engines & engine parts	15,900
24	3728	Aircraft equipment, n.e.c.	15,870
25	2421	Sawmills and Planing Mills - General	15,244

Source: Department of Commerce

PLASTICS PROCESSING COMPANIES *

SALES DOLLAR BREAKDOWN



• Includes custom processors and proprietary processors.

PLASTICS PROCESSING INDUSTRY

BY SALES GROUPS--1988

BALANCE SHEET[1] (Number of Responses*)	TOTAL [157]	SALES VOLUME < $5MM [52]	$5.10MM [27]	$10.25MM [46]	> $25MM [31]
Cash and Marketable Securities	5.6	7.5	4.4	6.1	3.2
Accounts Receivable	27.4	28.8	29.5	28.1	22.2
Raw Materials	11.3	12.0	11.7	11.4	9.4
Work in Progress	2.7	2.6	3.8	2.3	2.2
Finished Goods	7.9	6.3	8.2	8.5	8.7
LIFO Reserve	(1.4)	(0.3)	(1.3)	(2.1)	(2.0)
Inventory, Total	20.2	20.5	22.2	19.8	18.6
Packaging & Shipping Supplies	0.4	0.5	0.4	0.3	0.2
Other	2.7	2.9	3.0	2.2	2.9
Other Current Assets Total	3.1	3.4	3.3	2.5	3.4
TOTAL CURRENT ASSETS	55.3	59.5	59.4	53.9	46.8
Land and Buildings (net of depreciation)	11.5	9.3	9.3	12.5	15.7
Machinery and Equipment (net of depreciation)	26.3	25.3	24.7	25.6	30.1
Other Long Term Assets	6.5	5.2	6.4	7.3	7.3
TOTAL ASSETS	100.0	100.0	100.0	100.0	100.0
Accounts Payable	16.7	15.7	19.1	17.4	15.1
Other Current Liabilities	9.0	6.9	8.9	12.3	8.0
Notes Payable	9.4	14.0	7.1	8.1	5.0
Current Portion of Long Term Debt	4.5	6.1	4.7	3.6	3.0
TOTAL CURRENT LIABILITIES	39.8	43.2	39.9	41.8	31.2
Long Term Debt (less current portion)	9.5	8.1	7.7	9.2	13.8
TOTAL LIABILITIES	48.9	51.4	44.9	51.0	45.0
EQUITY (NET WORTH)	51.0	48.6	52.9	49.8	55.0
INCOME STATEMENT[2]					
NET SALES	100.0	100.0	100.0	100.0	100.0
Direct Materials	42.2	37.1	41.6	44.7	47.5
Direct Labor	10.8	14.8	9.8	9.7	7.2
Indirect Labor	6.3	5.7	7.6	6.0	6.5
Manufacturing Personnel Fringe Benefits	3.9	3.4	4.0	4.2	3.9
Depreciation Expense	3.3	3.8	3.3	2.9	3.4
Other Manufacturing Expense	11.8	11.1	12.5	11.7	12.4
Total Production Related Expenses (COGS)	78.2	75.7	78.4	79.1	80.4
GROSS MARGIN	21.8	24.3	21.6	20.9	19.6
Sales Salaries, Commissions, Fringe Benefits	3.3	3.8	3.4	3.3	2.6
Other Selling Expense	1.8	1.9	1.3	1.6	2.2
Administrative Expense (includes Engineering & R&D Salaries)	9.0	12.9	9.9	7.1	5.4
Other Engineering/R&D Expense	0.6	0.5	0.2	0.7	0.7
Total Non-Production Related Expenses (SG&A)	14.5	18.8	14.5	12.5	10.9

Some companies did not respond to every line item, therefore the sum of the average breakouts may not equal the average total.
*One company did not provide net sales, therefore their data appears in the total column only
1 Averages as a percent of Total Assets. 2 Averages as a percent of Net Sales.
Source: SPI Financial & Operating Ratios Survey

PLASTICS PROCESSING INDUSTRY

BY SALES GROUPS--1988

(CONCLUDED)

INCOME STATEMENT [2] (CONCLUDED)	TOTAL [157]	SALES VOLUME			
		< $5MM [52]	$5.10MM [27]	$10.25MM [46]	> $25MM [31]
OPERATING MARGIN	7.3	5.5	7.1	8.3	8.7
Interest Expense (Income)	1.2	1.6	1.1	0.7	1.3
Other Expense (Income)	0.4	0.1	0.8	0.5	0.1
Profit Before Income Taxes	5.8	3.8	5.0	7.1	7.4
Income Taxes	1.4	0.5	1.7	1.7	1.8
Profit After Income Taxes	4.4	3.3	3.4	5.2	5.6
STATISTICAL DATA [3]					
Net Sales/Average Number Employees	$ 103,943	$ 75,818	$ 87,257	$ 114,473	$ 148,923
Net Sales/All Employee Hours	$ 32	$ 38	$ 44	$ 56	$ 73
Net Sales/Production Worker Hours	$ 82	$ 65	$ 65	$ 95	$ 104
Total Employment Costs/Net Sales	29.7%	36.3%	31.0%	27.2%	23.4%
Production Worker Employment Costs/Net Sales	21.0%	23.9%	21.8%	19.8%	17.5%
Total Employment Costs/LBS. Processed	$ 1.06	$ 1.31	$ 1.46	$ 0.76	$ 0.92
Production Worker Employment Costs/LBS. Processed	$ 0.74	$ 0.88	$ 0.96	$ 0.56	$ 0.63
COGS/LBS. Processed	$ 2.67	$ 2.71	$ 3.55	$ 2.14	$ 2.71
Productive Machine Hrs./Available Machine Hrs.	54.8%	43.8%	53.3%	57.9%	68.2%
Inventory Turnover (times)	11.2	12.0	9.0	11.9	10.6
Average Collection Period (days)	49	49	50	47	48
Return on Assets (before tax)	12.6%	8.9%	13.3%	15.3%	13.4%
Return on Equity (before tax)	35.6%	41.2%	33.5%	34.4%	30.0%
Return on Assets (after tax)	9.6%	8.1%	8.8%	11.2%	10.0%
Return on Equity (after tax)	29.4%	41.7%	22.0%	26.1%	21.7%
Percent Change in Net Sales (1987-1988)	21.4%	17.2%	15.9%	28.9%	22.6%

[2] Averages as a percent of Net Sales.

[3] Each average is calculated using only those companies providing data necessary for the respective calculation.

Source: SPI Financial & Operating Ratios Survey.

Major Markets

CATEGORIES

The primary product groups for each Major Market category are listed below:

A. TRANSPORTATION

Motor Vehicles and Parts: including autos, trucks, buses, motorcycles, and bicycles
All Other: including railroad equipment, travel trailers, campers, golf carts, snowmobiles, aircraft, military vehicles, ships, boats and recreational vehicles.

B. PACKAGING

Bottles, Jars, Vials
Food Containers: excluding disposable cups
Flexible Packaging: including household and institutional refuse bags and film
All Other: including tubes, tape, strapping, drums, caps, baskets, trays, boxes, pallets, shipping crates, pails, buckets, shipping cases, blister and bubble containers.

C. BUILDING AND CONSTRUCTION

Pipe, Conduit and Fittings: including drainage, irrigation, plumbing fixtures, and septic tanks
Building Material for all Structures: including siding, flooring, and insulation materials
All Other: including panels, doors, windows, skylights, bathroom units, gratings and railings.

D. ELECTRICAL/ELECTRONIC

Home and Industrial Appliances: including electrical industrial equipment, wire and cable coverings, communications equipment
Electronic Components: including resistors, magnetic tape, records, and batteries.

E. FURNITURE AND FURNISHINGS

Rigid and Flexible Types: including household and office furniture, bedding, carpets, rugs, backing, curtains, blinds, awnings, lamps, picture frames, and wall coverings.

F. CONSUMER AND INSTITUTIONAL PRODUCTS

Disposable Food Serviceware: including disposable cups
Dinner and Kitchenware: including picnicware
Toys and Sportings Goods
Health Care and Medical Products: including laboratory supplies
Hobby and Graphic Arts Supplies: including photographic equipment and supplies
All Other: including footwear, luggage, buttons, lawn & garden tools, signs & displays, and credit cards.

G. INDUSTRIAL/MACHINERY

All Types: including engine and turbine parts, farm and garden machinery, construction and related equipment, machine tools, ordnance and firearms, and chemical process equipment.

H. ADHESIVES/INKS/COATINGS

Adhesives and Sealants
All Other: including printing ink, magnet wire enamels, core binders, foundry facings, paper coating and glazing, paints, varnishes, and enamels.

I. ALL OTHER

Sales of Resins Sold to Resellers and Compounders
Other sales of resins which cannot be classified under any Major Market category A through H.

J. EXPORTS

Sales of Plastic Resin exported from the U.S.

1988

The 1988 data reflect major market plastics resins sales and captive use data compiled by Ernst & Whinney with data reported by individual resin. The plastic resin categories included in this study are:

THERMOSETS

Epoxy
Polyester, Unsaturated
Urea and Melamine
Phenolic

THERMOPLASTICS

Low Density Polyethylene
High Density Polyethylene
Polypropylene
Acrylonitrile-Butadiene-Styrene (ABS) and Styrene-Acrylonitrile (SAN)
Polystyrene
Styrene Butadiene Latexes (SBL), and Other Styrene Based Latexes (OSBL), and Other Styrene Based Polymers (OSBP)
Nylon
Polyvinyl Chloride
Other Vinyls
Thermoplastic Polyester
Engineering Resins

TOTAL RESIN SALES & CAPTIVE USE

BY MAJOR MARKET

(millions of pounds, dry weight basis)

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	2,109	1,989	1,988	2,029	2,278
Packaging	12,398	12,774	13,267	15,234	16,068
Building and Construction	9,691	10,038	10,085	11,285	11,449
Electrical/Electronic	2,757	2,659	2,609	2,779	3,024
Furniture and Furnishings	2,117	2,107	2,191	2,235	2,138
Consumer and Institutional	3,986	3,975	4,123	5,063	5,210
Industrial/Machinery	400	364	361	332	744
Adhesives/Inks/Coatings	1,993	2,142	1,638	1,797	1,245
All Other	4,080	5,122	4,555	4,665	9,337
Exports	3,796	4,170	4,206	4,593	*
Total	**43,327**	**45,340**	**45,023**	**50,012**	**51,493**

*Amount is included in All Other.

COMPARATIVE PERCENTAGE DISTRIBUTION

BY MAJOR MARKET

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	4.9%	4.4%	4.4%	4.1%	4.4%
Packaging	28.6	28.2	29.5	30.4	31.2
Building and Construction	22.4	22.1	22.4	22.6	22.2
Electrical/Electronic	6.4	5.9	5.8	5.6	5.9
Furniture and Furnishings	4.9	4.7	4.9	4.5	4.2
Consumer and Institutional	9.2	8.8	9.2	10.0	10.1
Industrial/Machinery	0.8	0.8	0.8	0.7	1.5
Adhesives/Inks/Coatings	4.6	4.7	3.6	3.6	2.4
All Other	9.4	11.2	10.1	9.3	18.1
Exports	8.8	9.2	9.3	9.2	-
Total	100.0%	100.0%	100.0%	100.0%	100.0%

PERCENTAGE CHANGE IN SALES AND USE

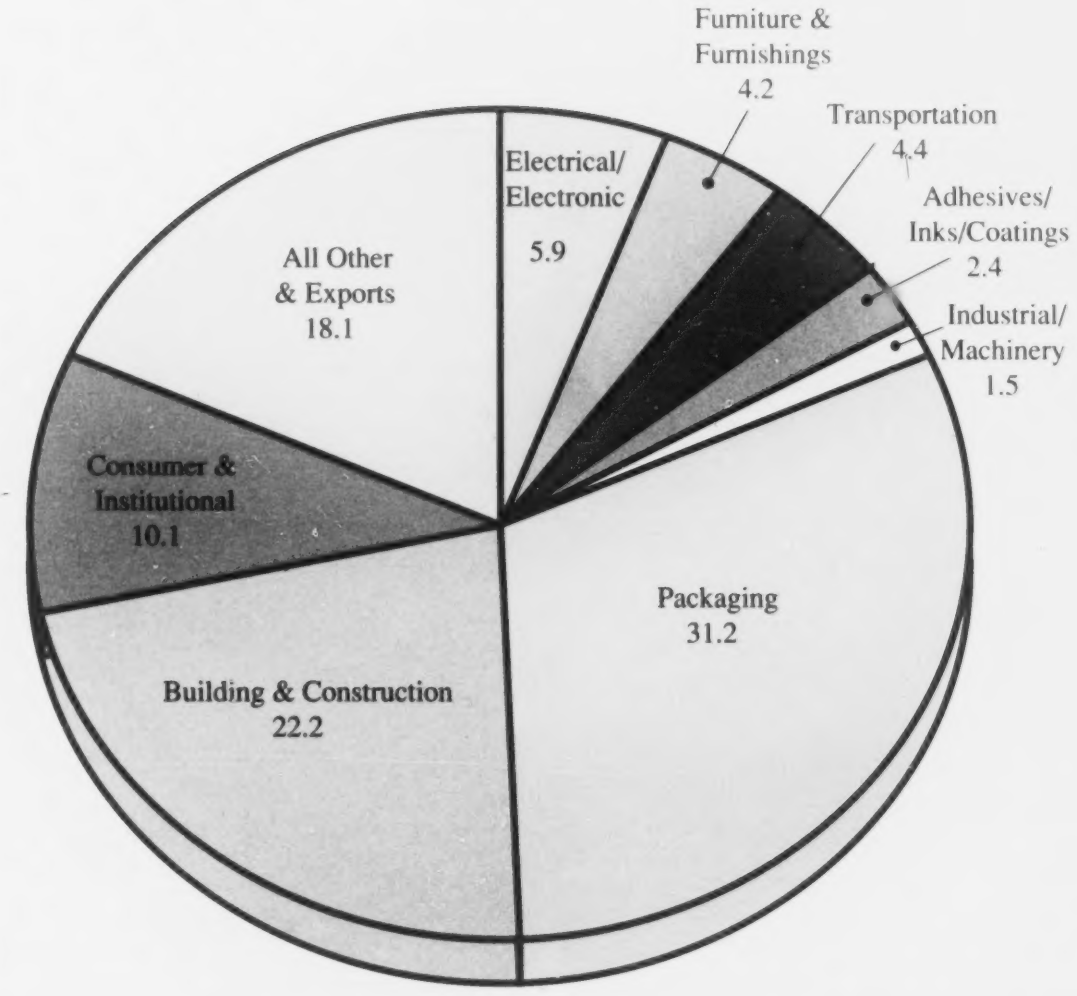
BY MAJOR MARKET

MAJOR MARKET	% CHANGE 1986/1987	% CHANGE 1987/1988
Transportation	2.1%	12.3%
Packaging	14.8	5.5
Building and Construction	11.9	1.5
Electrical/Electronic	6.5	8.8
Furniture and Furnishings	2.0	-4.4
Consumer and Institutional	22.8	2.9
Industrial/Machinery	-8.0	24.1
Adhesives/Inks/Coatings*	9.7	-30.7
All Other	2.4	20.0
Exports	9.2	NA
Total*	11.1%	3.0%

* % change approximate, due to reporting changes in 1986
NA = Not Available

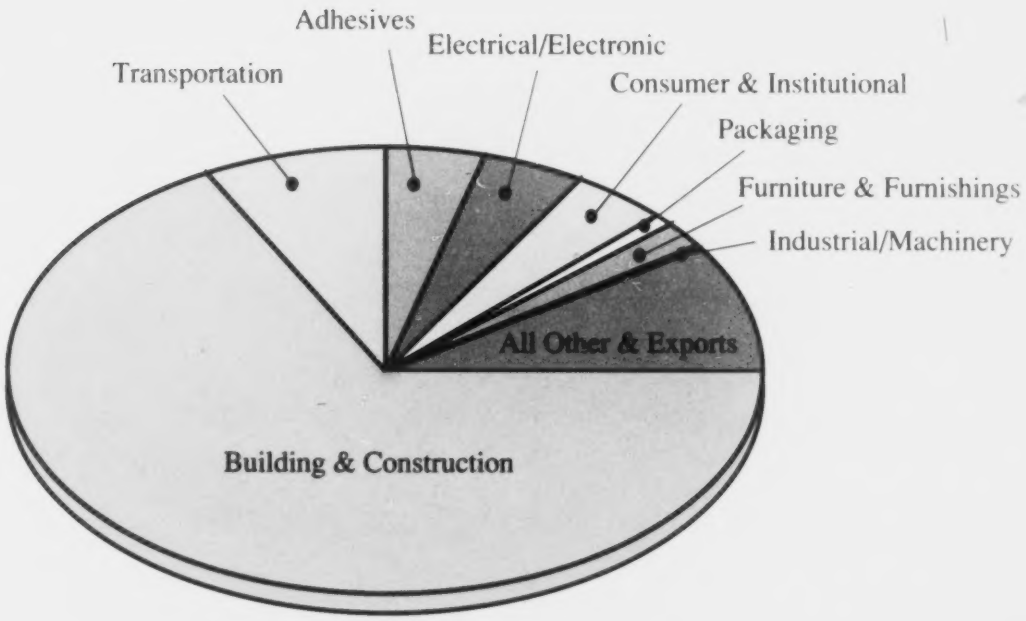
1988 DISTRIBUTION OF PLASTIC RESIN SALES & CAPTIVE USE BY MAJOR MARKET

ALL RESINS

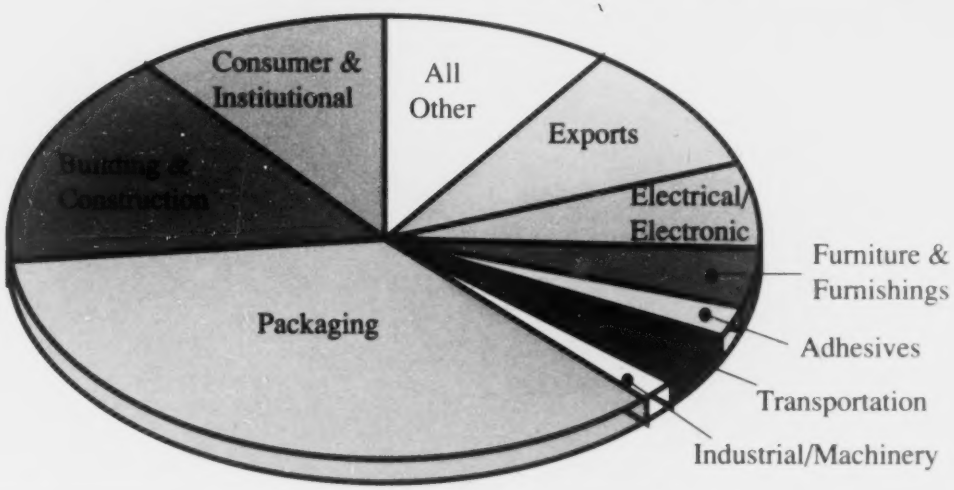


1988 DISTRIBUTION OF PLASTIC RESIN SALES & CAPTIVE USE BY MAJOR MARKET

THERMOSET RESINS



THERMOPLASTIC RESINS



1988 DISTRIBUTION OF PLASTIC RESINS SALES & CAPTIVE USE

Total Thermosets & Thermoplastics

(Thousands of Pounds, Dry Weight Basis)^1

MAJOR MARKET	TOTAL THERMOSETS		TOTAL THERMOPLASTICS		GRAND TOTAL	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	486,779	7.50%	1,791,585	3.98%	2,278,364	4.43%
PACKAGING, TOTAL	59,326	0.92%	16,008,308	35.57%	16,067,634	31.20%
BUILDING AND CONSTRUCTION, TOTAL	4,366,104	67.31%	7,082,519	15.74%	11,448,623	22.23%
ELECTRICAL/ELECTRONIC, TOTAL	291,388	4.49%	2,732,779	6.07%	3,024,167	5.87%
FURNITURE AND FURNISHINGS, TOTAL	121,290	1.87%	2,016,238	4.48%	2,137,528	4.15%
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	263,356	4.06%	4,947,014	10.99%	5,210,370	10.12%
INDUSTRIAL/MACHINERY, TOTAL	28,316	0.44%	715,681	1.59%	743,997	1.45%
ADHESIVES/INKS/COATINGS, TOTAL	273,166	4.21%	972,177	2.16%	1,245,343	2.42%
ALL OTHER, TOTAL ^2	596,784	9.20%	4,374,196	9.72%	9,336,959	18.13%
EXPORTS, TOTAL	D		4,365,979	9.70%	D	
GRAND TOTAL	6,486,509	100.00%	45,006,476	100.00%	51,492,985	100.00%

^1 - Phenolic is on a Gross Weight Basis

D = Disclosure, amount is included in All Other, Total.

^2 - Disclosure Data is included in All Other, Total for individual resins (pp. 28 - 30). However, for resin class totals above, such disclosure data can be distributed by Major Market category without any disclosure. Therefore, All Other, Total as shown above, is less than the sum of All Other, Total for Thermoset and Thermoplastic resins (pp. 28 - 30).

Compiled By Ernst & Whinney, Washington, D.C., for SPI's Committee on Resin Statistics (CRS)

1988 DISTRIBUTION OF PLASTIC RESINS SALES & CAPTIVE USE

Thermoset/Thermoplastic Resins

(Thousands of Pounds, Dry Weight Basis)^1

MAJOR MARKET	EPOXY		POLYESTER		UREA & MELAMINE		PHENOLICS		LOW DENSITY PE	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	D		397,204	28.51%	D		61,056	1.99%	92,115	0.91%
PACKAGING, TOTAL	5,290	1.13%	D		36,299	2.34%	D		5,928,699	58.25%
BUILDING AND CONSTRUCTION, TOTAL	51,016	10.90%	491,306	35.26%	1,211,916	78.07%	2,611,866	85.00%	340,798	3.35%
ELECTRICAL/ELECTRONIC, TOTAL	88,731	18.95%	40,239	2.89%	D		D		D	
FURNITURE AND FURNISHINGS, TOTAL	8,326	1.78%	31,087	2.23%	21,098	1.36%	60,779	1.98%	48,144	0.47%
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	3,683	0.79%	131,812	9.46%	D		D		865,639	8.51%
INDUSTRIAL/MACHINERY, TOTAL	D		19,475	1.40%	0	0.00%	D		272,457	2.68%
ADHESIVES/INKS/COATINGS, TOTAL	D		13,914	1.00%	D		52,089	1.69%	393,260	3.86%
ALL OTHER, TOTAL	218,770	46.74%	252,367	18.11%	282,975	18.23%	264,860	8.62%	1,330,290	13.07%
EXPORTS, TOTAL	92,259	19.71%	15,882	1.14%	D		22,210	0.72%	906,029	8.90%
GRAND TOTAL	468,075	100.00%	1,393,286	100.00%	1,552,288	100.00%	3,072,860	100.00%	10,177,431	100.00%

^1 - Phenolic is on a Gross Weight Basis
D = Disclosure, amount is included in All Other, Total.

Compiled By Ernst & Whinney, Washington, D.C., for SPI's Committee on Resin Statistics (CRS)

1988 DISTRIBUTION OF PLASTIC RESINS SALES & CAPTIVE USE

Thermoplastic Resins

(Thousands of Pounds, Dry Weight Basis)

MAJOR MARKET	HIGH DENSITY PE		POLYPROPYLENE		ABS & SAN		POLYSTYRENE		STYRENE LATEX & OSBP	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	144,932	1.79%	438,467	6.19%	314,407	22.07%	5,775	0.11%	D	
PACKAGING, TOTAL	4,731,365	58.53%	1,632,431	23.03%	2,681	0.19%	1,725,963	34.34%	D	
BUILDING AND CONSTRUCTION, TOTAL	829,734	10.26%	151,134	2.13%	146,987	10.32%	505,992	10.06%	36,132	3.07%
ELECTRICAL/ELECTRONIC, TOTAL	135,429	1.67%	195,734	2.76%	D		610,555	12.15%	84,482	7.18%
FURNITURE AND FURNISHINGS, TOTAL	D		1,218,088	17.19%	D		127,009	2.53%	321,336	27.33%
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	659,285	8.16%	1,101,650	15.54%	258,966	18.17%	1,306,225	25.99%	17,340	1.48%
INDUSTRIAL/MACHINERY, TOTAL	161,215	1.99%	83,956	1.18%	D		0	0.00%	D	
ADHESIVES/INKS/COATINGS, TOTAL	24,707	0.31%	D		D		0	0.00%	392,068	33.34%
ALL OTHER, TOTAL	748,585	9.26%	1,086,816	15.33%	701,896	49.25%	583,875	11.61%	324,537	27.60%
EXPORTS, TOTAL	648,938	8.03%	1,179,789	16.65%	N/A		161,171	3.21%	D	
GRAND TOTAL	8,084,190	100.00%	7,088,065	100.00%	1,424,937	100.00%	5,026,565	100.00%	1,175,895	100.00%

D = Disclosure, amount is included in All Other, Total.
N/A = Not Available. Amount is included in All Other, Total.

Compiled By Ernst & Whinney, Washington, D.C., for SPI's Committee on Resin Statistics (CRS)

1988 DISTRIBUTION OF PLASTIC RESINS SALES & CAPTIVE USE

Thermoplastic Resins

(Thousands of Pounds, Dry Weight Basis)

MAJOR MARKET	NYLON		PVC		OTHER VINYL		THERMOPLASTIC POLYESTER		ENGINEERING	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	164,035	28.56%	152,859	1.84%	35,582	17.10%	D		D	
PACKAGING, TOTAL	77,365	13.47%	702,968	8.48%	D		1,088,387	66.26%	21,724	1.65%
BUILDING AND CONSTRUCTION, TOTAL	26,165	4.55%	4,919,797	59.37%	D		D		D	
ELECTRICAL/ELECTRONIC, TOTAL	81,403	14.17%	559,143	6.75%	0	0.00%	D		D	
FURNITURE AND FURNISHINGS, TOTAL	31,680	5.52%	248,909	3.00%	D		D		D	
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	31,298	5.45%	558,270	6.74%	D		D		91,461	6.94%
INDUSTRIAL/MACHINERY, TOTAL	37,137	6.47%	26,116	0.32%	0	0.00%	5,798	0.35%	45,262	3.44%
ADHESIVES/INKS/COATINGS, TOTAL	5,396	0.94%	136,329	1.65%	D		D		D	
ALL OTHER, TOTAL	40,401	7.03%	465,824	5.62%	106,596	51.24%	319,739	19.46%	883,382	67.05%
EXPORTS, TOTAL	79,466	13.84%	516,510	6.23%	65,881	31.66%	228,838	13.93%	275,672	20.92%
GRAND TOTAL	574,346	100.00%	8,286,725	100.00%	208,059	100.00%	1,642,762	100.00%	1,317,501	100.00%

D = Disclosure, amount is included in All Other, Total.

Compiled By Ernst & Whinney, Washington, D.C., for SPI's Committee on Resin Statistics (CRS)

Resin Statistics

PLASTIC RESINS: 1963-1988

TOTAL U.S. PRODUCTION AND SALES & CAPTIVE USE *

(in millions of pounds)

YEAR	PRODUCTION (Including Polyurethane)	SALES & CAPTIVE USE (Including Polyurethane)
[a]1963	9,364	7,632
1964	10,525	8,847
1965	12,219	11,035
1966	14,199	11,726
1967	14,473	12,284
1968	17,231	15,396
1969	19,720	16,495
1970	20,056	17,494
[c]1971	21,161	19,813
1972	26,475	25,504
1973	29,213	28,719
1974	29,274	27,890
1975	22,828	22,278
1976	29,196	28,379
1977	33,948	32,771
1978	37,605	36,818
1979	41,577	40,607
1980	37,347	36,896
1981	39,867	38,801
1982	36,607	36,639
1983	42,777	42,212
1984	46,336	45,221
1985	47,946	47,470
[d]1986	50,849	50,452
[d]1987	55,751	55,818
[d]1988	59,762	58,554

[a] U.S. Tariff Commission data used for 1963-1970. May exclude some captive use.
[b] Cellulosics included beginning in 1963.
[c] SPI data used for 1971-1988.
[d] 1986-1988 includes SPI Estimates.

COMPOUND GROWTH RATE

Years	Total Production	Sales & Captive Use
1963-1988	7.7%	8.5%
1973-1988	4.9%	4.9%
1978-1988	4.7%	4.7%
1983-1988	7.0%	6.7%
1987-1988	7.2%	4.9%

* Sales and Captive Use is Defined as Merchant Sales and Intra-Company Captive Use.

TOTAL U.S. PLASTICS BY RESIN

PRODUCTION and SALES & CAPTIVE USE

(in millions of pounds)

RESIN	1978		1979		1980		1981		1982	
	P	S&CU	P	S&CU	P	S&CU	P	S&CU	P	S&CU
Epoxy	299	316	361	332	315	319	336	332	286	301
Phenolic	1,617	1,543	1,781	1,732	1,499	1,517	2,333	2,375	2,006	2,060
Polyester	1,209	1,199	1,147	1,152	947	949	997	977	865	851
Urea	1,122	1,103	1,367	1,355	1,165	1,147	1,165	1,139	998	976
Melamine	202	196	200	192	167	166	179	175	158	155
Total Selected Thermosets	4,449	4,357	4,856	4,763	4,093	4,098	5,010	4,998	4,313	4,343
ABS	1,134	1,118	1,191	1,183	920	916	916	900	740	737
SAN	120	121	124	126	111	103	107	105	91	85
HDPE	4,201	4,165	5,010	4,893	4,405	4,394	4,695	4,683	4,928	5,024
LDPE	7,111	7,147	7,793	7,815	7,291	7,467	7,693	7,516	7,503	7,687
Nylon	275	278	327	315	274	271	312	288	228	247
Polypropylene	3,074	3,055	3,841	3,894	3,648	3,714	3,955	3,888	3,477	3,623
Polystyrene	3,823	3,870	4,005	3,997	3,521	3,518	3,621	3,604	3,191	3,200
PVC	5,723	5,810	6,119	6,138	5,470	5,407	5,707	5,601	5,326	5,455
Thermoplastic Polyester	--	--	--	--	503	511	610	581	648	619
Total Selected Thermoplastics	25,461	25,564	28,410	28,361	26,143	26,301	27,616	27,166	26,132	26,677
Total Selected Plastics	29,910	29,921	33,266	33,124	30,236	30,399	32,626	32,164	30,445	31,020
All Other Plastics	7,695	6,897	8,311	7,483	7,111	6,497	7,241	6,637	6,162	5,619
Grand Total	**37,605**	**36,818**	**41,577**	**40,607**	**37,347**	**36,896**	**39,867**	**38,801**	**36,607**	**36,639**

COMPOUND GROWTH RATE 1978-1988

SALES & CAPTIVE USE

Epoxy	4.0%
Phenolic	**
Polyester	1.5%
Urea	2.0%
Melamine	0.5%
Total Selected Thermosets	**
ABS	1.3%
SAN	1.9%
HDPE	6.8%
LDPE	3.6%
Nylon	7.5%
Polypropylene	8.8%
Polystyrene	2.7%
PVC	3.6%
Thermoplastic Polyester	NA
Total Selected Thermoplastics	5.3%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

TOTAL U.S. PLASTICS BY RESIN

PRODUCTION and SALES & CAPTIVE USE (Cont'd)

(in millions of pounds)

1983		1984		1985		1986		1987		1988	
P	S&CU	P	S&CU	P	S&CU	P	S&CU	P	S&CU	P	S&CU
334	331	406	379	385	367	398	375	433	419	486	468
2,484	2,529	2,502	2,510	2,621	2,640	2,735	2,771	2,869	2,871	3,066	3,073
1,084	1,072	1,232	1,231	1,223	1,233	1,271	1,265	1,367	1,362	1,404	1,393
1,172	1,167	1,199	1,189	1,210	1,203	1,271	1,266	1,382	1,368	1,425	1,350
180	181	210	197	192	194	173	191	212	198	207	203
5,254	5,280	5,549	5,506	5,631	5,637	5,848	5,868	6,263	6,218	6,588	6,487
NA	NA	1,128	1,098	1,028	1,016	1,092	1,080	1,175	1,208	1,277	1,279
93	91	99	88	87	84	92	87	126	127	148	146
5,691	5,707	6,085	5,949	6,671	6,651	7,182	7,028	7,995	8,155	8,400	8,084
8,041	8,045	8,413	8,416	8,889	8,790	8,903	8,799	9,599	9,611	10,397	10,177
321	329	396	389	399	403	465	443	507	499	566	574
4,434	4,464	4,940	4,816	5,139	5,275	5,812	5,824	6,647	6,720	7,274	7,088
3,567	3,606	3,838	3,836	4,054	4,108	4,470	4,463	4,780	4,860	5,187	5,027
6,066	6,152	6,760	6,798	6,772	6,720	7,256	7,412	7,971	8,081	8,350	8,287
778	783	899	859	965	956	1,175	1,160	1,394	1,410	1,652	1,643
28,991	29,177	32,558	32,249	34,004	34,003	36,447	36,296	40,194	40,671	43,251	42,305
34,245	34,457	38,107	37,755	39,635	39,640	42,295	42,164	46,457	46,889	49,839	48,792
8,532	7,755	8,229	7,466	8,311	7,830	8,554	8,288	9,294	8,929	9,923	9,762
42,777	**42,212**	**46,336**	**45,221**	**47,946**	**47,470**	**50,849**	**50,452**	**55,751**	**55,818**	**59,762**	**58,554**

COMPOUND GROWTH RATE 1978-1988

SALES & CAPTIVE USE (Cont'd)

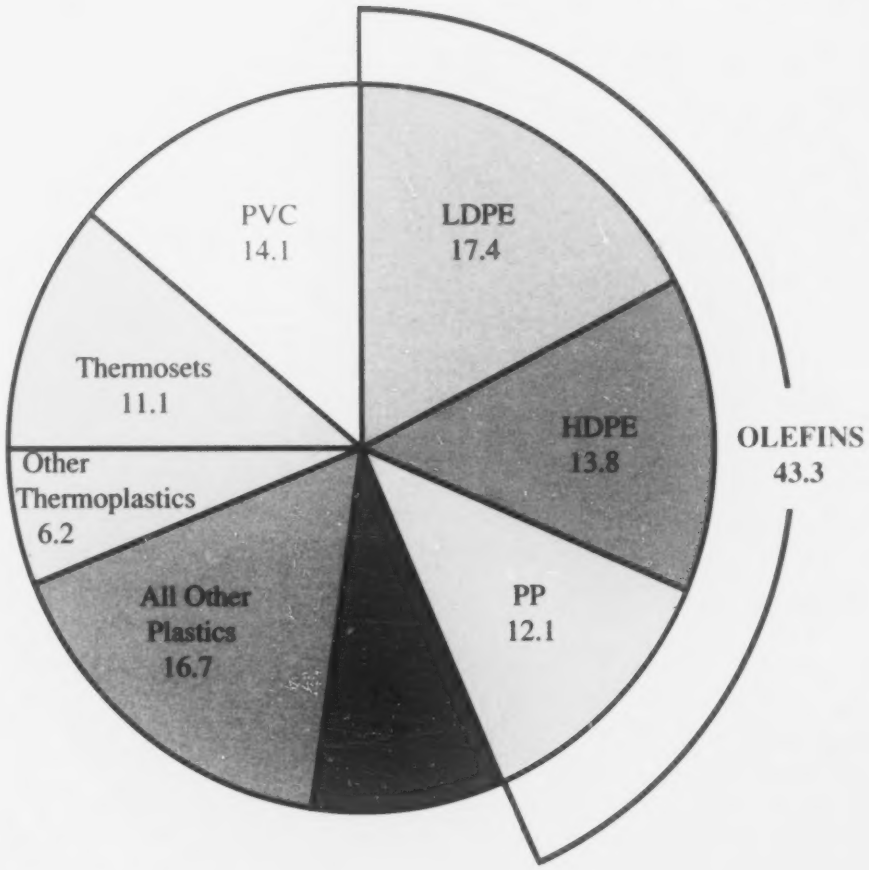
Total Selected Plastics	5.0%
All Other Plastics*	3.6%
Grand Total	**4.7%**

P = Production S & C = Sales & Captive Use NA = Not Available
**Not applicable since reporting on gross weight basis begun in 1981
* 1986 - 1988 Includes SPI Estimates

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

PERCENTAGE DISTRIBUTION OF PLASTIC

SALES & CAPTIVE USE BY MATERIAL



PLASTIC RESINS

DOMESTIC MERCHANT SALES

(in millions of dollars and millions of pounds)

Resin	1988		1987		% Change	
	Net Dollar Value	Quantity	Net Dollar Value	Quantity	Net Dollar Value	Quantity
Low Density Polyethylene	$ 4,151	8,544	$ 2,720	8,180	52.6	4.4
Polyvinyl Chloride	2,874	7,085	2,143	6,533	34.1	8.4
High Density Polyethylene	3,294	7,147	2,162	7,002	52.4	2.1
Polystyrene	2,689	4,202	2,024	4,329	32.9	-2.9
Polypropylene	2,289	4,903	1,670	4,498	37.1	9.0
ABS	962	1,069	784	1,037	22.7	3.1
Other Styrenes	874	1,129	751	1,075	16.4	5.0
Unsaturated Polyester	779	1,315	765	1,306	1.8	0.7
Thermoplastic Polyester	1,044	1,414	815	1,187	28.1	19.1
Nylon	666	444	583	396	14.2	12.1
Phenolic	540	2,886	405	2,092	33.3	38.0
Epoxy	472	376	415	344	13.7	9.3
Other Vinyls	155	92	142	110	9.2	-16.4
Urea	216	1,320	184	1,195	17.4	10.5
Melamine	178	189	178	186	0.0	1.6
SAN	51	69	48	90	6.3	-23.4
Engineering Resins	1,352	688	1,006	739	34.4	-6.9
Total	$ 22,586	42,872	$ 16,795	40,299	34.5	6.4

Domestic merchant sales are quantities of sales excluding interplant transfers, captive consumption and exports.
Net dollar value represents the actual selling price after deductions for cash discounts, quantity discounts, returned goods and allowances, federal excise taxes, local taxes, and outgoing transportation (prepaid or otherwise) to warehouses or customers.

Source: SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

APPARENT U.S. CONSUMPTION OF SELECTED PLASTIC RESINS

Apparent consumption is calculated by adding imports to production then subtracting exports. It is an accurate measure of the quantity of material actually consumed in the United States.

For purposes of the table below, the production figures were taken from SPI's Monthly Statistical Report, as compiled by Ernst & Whinney. Both the import and export figures were taken from Bureau of the Census reports.

1988

(in millions of pounds)

RESIN	Production (plus)	Imports (minus)	Exports (equals)	Apparent Consumption	Import % Of Apparent Consumption
Low Density Polyethylene	10,397	831	1,038	10,190	8
High Density Polyethylene	8,400	92	784	7,708	1
PVC	8,350	114	446	8,018	1
Polypropylene	7,274	33	1,615	5,692	1
Polystyrene	5,187	23	190	5,020	0
Phenolic	3,066	45	61	3,050	1
Styrene Copolymers (inc. ABS)	2,565	100	479	2,186	4
Thermoplastic Polyester[a]	1,652	32	160	1,524	2
Urea	1,425	24	8	1,441	2
Unsaturated Polyester	1,404	7	56	1,355	1
Nylon	566	54	143	477	11
Epoxy	486	13	92	407	3
Melamine	207	6	16	197	3
Other Vinyls	222	48	83	187	26
1988 TOTAL	**51,201**	**1,422**	**5,171**	**47,452**	**3**
1987 Total	47,898	1,334	4,764	44,468	3
1986 Total	43,595	1,308	3,965	40,938	3
1985 Total	40,836	1,205	3,552	38,489	3
1984 Total	39,293	899	3,484	36,708	2
1983 Total	37,145	581	3,767	33,959	2
1982 Total	31,262	268	4,102	27,428	1
1981 Total	33,696	307	3,596	30,407	1
1980 Total	31,247	247	4,194	27,300	1
1979 Total	34,550	273	3,625	31,198	1
1978 Total	31,101	234	2,302	29,033	1
1977 Total	28,077	136	1,978	26,235	1

[a]Not included in total 1977-1979

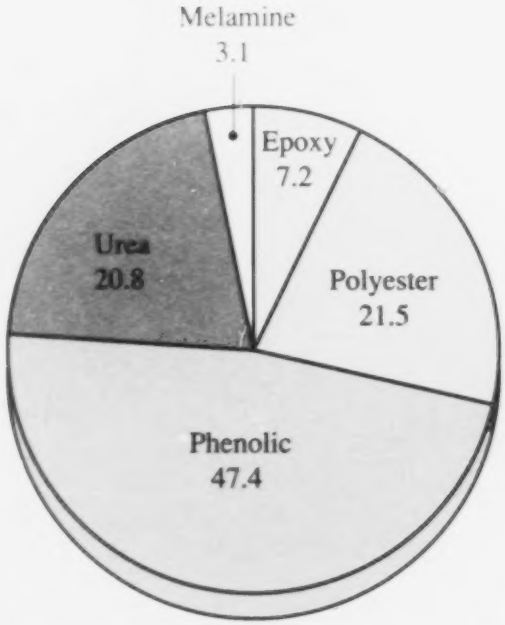
Source: Production--SPI Monthly Statistical Report, as compiled by Ernst & Whinney
Imports--Bureau of the Census, IM 146
Exports--Bureau of the Census, EM 546

Thermoset Resins

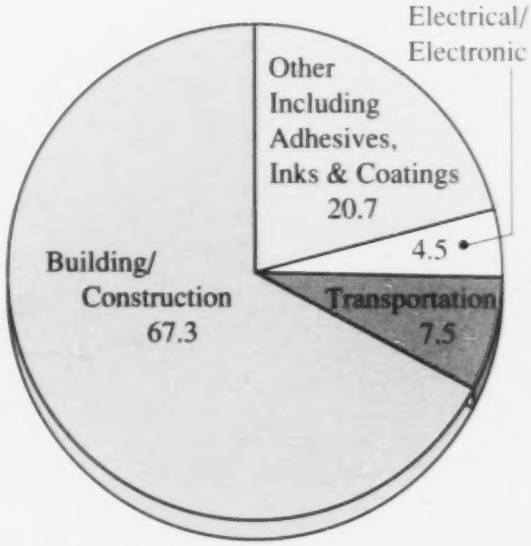
SUMMARY STATISTICS

Plastics which in their final state as finished articles are substantially infusible and insoluable. They are often liquids at some state of their manufacture or processing, which are cured by heat, catalysts or other chemical means. After being fully cured, thermosets cannot be resoftened by heat.

1988 PERCENT OF THERMOSET SALES & CAPTIVE USE



1988 PERCENT BY MATERIAL



1988 PERCENT BY MAJOR MARKET

NOTE: Includes data from reporting companies only. No estimates are included.

Source: SPI Major Market Report, SPI Comittee on Resin Statistics as compiled by Ernst & Whinney

EPOXY

MANUFACTURERS*

Ciba-Geigy Corp.
Dow Chemical U.S.A
Interez, Inc.
Reichhold Chemicals, Inc.
Shell Chemical Co.
Union Carbide Corp.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1988

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1978	299	316
1979	361	332
1980	315	319
1981	336	332
1982	286	301
1983	334	331
1984	406	379
1985	385	367
1986	398	376
1987	433	419
1988	486	468
Average Annual Growth		
1978-1988	5.0%	4.0%

DOMESTIC CONSUMPTION BY END-USE

(millions of pounds)

END-USE	1984	1985	1986	1987	1988
Bonding & adhesives	20	17	19	22	23
Flooring, paving and aggregates	18	17	19	21	25
Protective coatings	153	168	160	171	179
Fiber reinforced laminates & composites	87	69	69	72	83
Tooling, casting, and molding resins	31	23	23	24	27
All other cases	29	31	29	34	39
Total	338	325	319	344	376

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

EPOXY

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	*	*	*	*	*
Packaging	*	*	*	*	5
Building and Construction	36	39	38	47	51
Electrical/Electronic	82	72	80	74	89
Furniture and Furnishings	*	*	*	*	8
Consumer and Institutional	*	*	*	*	4
Industrial/Machinery	*	*	*	*	*
Adhesives/Inks/ Coatings	122	140	140	148	*
All Other	98	74	61	69	219
Exports	41	42	57	75	92
Total	**379**	**367**	**376**	**419**	**468**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Coatings
Electrical laminates
Floor/paving aggregates
Reinforced composites
Electrical/Electronic casting
Industrial equipment
Adhesives and molding
Sealants

PHENOLIC

MANUFACTURERS*

Allied Bendix
Ametek, Haveg Div.
Ashland Chemical Co.
Borden Chemical Co., Inc.
Chembond Corp.
Formica Corp.
Georgia-Pacific Corp.
Hoechst Celanese
Inmont Corp.
Ironsides Resins, Inc.
Koppers Co.
Masonite Corp.
Occidental Chemical Corp.
Owens-Corning Fiberglas Corp.
Plaslok Corp.
Plastics Engineering Co.
Polyrez Co., Inc.
Reichhold Chemicals, Inc.
Rogers Corp.
Sterling Engineered Products
Union Carbide Corp.
Valchem
Valite Div., Valentine Sugars, Inc.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1988

PRODUCTION AND SALES & CAPTIVE USE[1]

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1978	1,827	1,788
1979	1,781	1,732
1980	1,499	1,517
1981	2,333	2,375
1982	2,006	2,060
1983	2,484	2,529
1984	2,502	2,510
1985	2,621	2,640
1986	2,735	2,771
1987	2,869	2,871
1988	3,066	3,073
Average Annual Growth		
1981-1988	3.9%	3.6%

[1] Gross weight basis of reporting began in 1981 so data are not comparable before then.

TYPICAL APPLICATIONS

Wiring devices
Connectors
Transmission parts
Pulleys
Electrical switch gear
Closures
Handles
Telephone relay systems
Rubber tackifiers
Laminating plywood
Knobs
Power brake components

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

PHENOLIC

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1984	1985	1986	1987	1988
Molding compounds	238	209	206	195	190
Bonding & adhesive resins for:					
Laminating	149	142	200	191	217
Coated & bonded abrasives	23	16	19	20	23
Friction materials	35	26	29	32	38
Insulation materials	307	419	425	435	503
Foundry & shell molding	81	77	42	44	53
Plywood	1,319	1,255	1,450	1,558	1,582
Fibrous & granulated wood	184	217	244	247	*
Resins sold to Rubber Industry	30	28	31	18	19
All other	62	159	66	35	328
Protective coatings	22	23	24	24	21
All other uses	38	48	20	54	77
Total	**2,488**	**2,619**	**2,756**	**2,853**	**3,051**

*Included in All Other
Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	150	124	85	63	61
Packaging	*	*	*	*	*
Building and Construction	1,921	1,950	2,278	2,394	2,612
Electrical/Electronic	162	128	130	122	*
Furniture and Furnishings	*	*	*	*	61
Consumer and Institutional	*	*	*	*	*
Industrial/Machinery	9	7	*	*	*
Adhesives/Inks/Coatings	80	82	68	67	52
All Other	166	328	194	207	265
Exports	22	21	16	18	22
Total	**2,510**	**2,640**	**2,771**	**2,871**	**3,073**

*Included in All Other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

UNSATURATED POLYESTER

MANUFACTURERS*

Advance Coatings Corp.
Alpha Chemical Corp.
Aristech Chemical Co.
Ashland Chemical Co.
Cook Paint & Varnish Co.
Dow Chemical U.S.A.
Freeman Chemical Corp.
Glidden Coatings & Resin Div. SCM Corp.
ICI Americas, Inc.
Inmont Corp. (BASF)
Interplastics Corp.
Koppers Co.
Owens-Corning Fiberglas Corp.
Reichhold Chemicals, Inc.
Sherex Polymers
SILMAR Div. of SOHIO Chem. Co.
Sterling Engineered Products

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1988

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1978	1,209	1,199
1979	1,147	1,152
1980	947	949
1981	997	977
1982	865	851
1983	1,084	1,072
1984	1,232	1,231
1985	1,223	1,233
1986	1,271	1,265
1987	1,367	1,362
1988	1,404	1,393
Average Annual Growth		
1978-1988	1.5%	1.5%

TYPICAL APPLICATIONS

Panels
Tanks
Auto components
Sanitary fixtures
Synthetic marble
Recreational vehicles
Pleasure boats
Bowling balls
Showerstalls

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

UNSATURATED POLYESTER

MAJOR DOMESTIC MARKETS

(in millions of pounds)

	1984	1985	1986	1987	1988
DOMESTIC REINFORCED PLASTICS, TOTAL	**939**	**949**	**947**	**1,030**	**1,050**
Marine and marine accessories	249	246	265	302	330
Transportation	99	120	107	106	107
Auto, trucks, buses, etc.	83	100	88	89	86
Other transportation	16	20	19	17	21
Construction	389	382	382	445	428
General construction	172	158	145	151	140
Bathroom components & fixtures, general purpose tanks & pipes	100	112	124	160	147
Corrosion resistant tanks, pipes, etc.	117	112	113	134	141
Electrical generation, transmission and distribution	37	27	27	26	28
Consumer goods	85	96	84	66	71
Major appliances and parts	19	21	21	20	21
Recreational goods, toys, etc.	39	42	32	23	28
Other consumer goods	27	33	31	23	22
Gel coats	41	38	42	45	48
Other reinforced	37	40	40	40	38
DOMESTIC NON-REINFORCED PLASTICS, TOTAL	**283**	**276**	**309**	**322**	**327**
Castings	161	160	173	184	186
Furniture	5	7	5	5	9
Cultured marble & onyx	107	107	121	131	128
Other	49	46	47	48	49
Autobody putty	56	61	69	72	66
Surface and protective coatings	5	6	8	8	15
Bonding and adhesives	3	2	4	2	3
Minebolt anchor resins	21	20	NA	26	26
Other non-reinforced	37	27	55	30	31

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	388	411	428	472	397
Packaging	--	--	--	*	*
Building/Construction	502	487	505	541	491
Electrical/Electronic	66	61	59	48	40
Furniture/Furnishings	11	11	11	22	31
Consumer & Instititutional	72	60	70	98	132
Industrial/Machinery	*	*	24	*	20
Adhesives, Inks & Coatings	*	*	*	*	14
All Other	184	194	159	171	252
Exports	8	9	9	10	16
Total	**1,231**	**1,233**	**1,265**	**1,362**	**1,393**

NA = Not Available *Included in all other

Sources: Quarterly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney
SPI Committee on Resin Statistics Annual Major Markets Survey

UREA

MANUFACTURERS*

American Cyanamid Co.
Borden Chemical Co., The
Chembond Corp.
Dan River, Inc.
Georgia-Pacific Corp.
Grifftex Chemicals, Inc.
Harborchem, Inc.
Interez, Inc.
Monsanto Co.
Perstorp Compounds, Inc.
Reichhold Chemicals, Inc.
Sterling Engineered Products
Valchem Sub., Air Products & Chemicals, Inc.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1988.

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1978	1,122	1,103
1979	1,367	1,355
1980	1,165	1,147
1981	1,165	1,139
1982	998	976
1983	1,172	1,167
1984	1,199	1,189
1985	1,210	1,203
1986	1,271	1,266
1987	1,382	1,368
1988	1,425	1,350
Average Annual Growth		
1978-1988	2.4%	2.0%

Sources: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

MELAMINE

MANUFACTURERS*

American Cyanamid Co.
Borden Chemical Co., The
Chembond Corp.
Formica Corp.
Grifftex Chemicals, Inc.
Harborchem, Inc.
Hoechst Celanese
Interez, Inc
Monsanto Co.
Perstorp Compounds, Inc.
Reichhold Chemicals, Inc.
Sterling Engineered Products

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1988

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1978	202	196
1979	200	192
1980	167	166
1981	179	175
1982	158	155
1983	180	181
1984	210	197
1985	192	194
1986	173	191
1987	212	198
1988	207	203
Average Annual Growth		
1978-1988	0.2%	-0.4%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

UREA AND MELAMINE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1984	1985	1986	1987	1988
Textile treating & coating resins	23	17	21	24	28
Paper treating & coating resins	98	100	97	80	54
Bonding & adhesive resins for:					
Laminating	44	45	45	51	42
Plywood	59	57	60	58	50
Fibrous & granulated wood	944	955	1,029	1,128	1,152
Protective coatings	84	89	102	110	111
All other uses	134	134	102	115	115
Total	**1,386**	**1,397**	**1,456**	**1,566**	**1,552**

NA = Not Available
Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	*	*	*	*	*
Packaging	32	30	33	31	36
Building and Construction	896	1,009	1,093	1,193	1,212
Electrical/Electronic	*	*	*	*	*
Furniture and Furnishings	*	43	37	38	21
Consumer and Institutional	*	116	*	*	*
Industrial/Machinery	--	--	--	--	--
Adhesives/Inks/Coatings	*	*	*	*	*
All Other	458	199	294	304	283
Exports	*	*	*	*	*
Total	**1,386**	**1,397**	**1,457**	**1,566**	**1,552**

*Included in All Other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

UREA

Wiring devices	Buttons
Toilet seats	Knobs
Handles	Adhesives and bonding

MELAMINE

Adhesives and bonding	Dinnerware
Buttons	Knobs
Handles	Ashtrays

ISOCYANATES

MANUFACTURERS*

BASF Corporation
Dow Chemical U.S.A.
ICI Americas, Inc.
Mobay Corporation
Olin Corporation

*Those manufacturers who participated in the SPI Monthly Isocyanates Report in 1988.

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

Production

Year	TDI	MDI	TOTAL
1984	680	651	1,331
1985	629	683	1,312
1986	654	692	1,346
1987	705	829	1,534
1988	741	935	1,676

Sales & Captive Use

Year		TDI	MDI	TOTAL
1984	**TOTAL**	**682**	**630**	**1,312**
	Domestic	534	517	1,051
	Export	148	113	261
1985	**TOTAL**	**628**	**666**	**1,294**
	Domestic	499	540	1,039
	Export	129	126	255
1986	**TOTAL**	**654**	**695**	**1,349**
	Domestic	498	572	1,070
	Export	156	123	279
1987	**TOTAL**	**702**	**814**	**1,516**
	Domestic	552	641	1,193
	Export	150	173	323
1988	**TOTAL**	**742**	**904**	**1,646**
	Domestic	574	700	1,274
	Export	168	204	372

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

POLYETHER POLYOLS

MANUFACTURERS*

ARCO Chemical Co.
BASF Corporation
Choate Chemical
Dow Chemical Company
E.I. duPont de Nemours & Co.
Mobay Chemical Co.
Olin Corp.
Q.O. Chemical
Stepan Corporation
Union Carbide Corp.
Witco Chemical Corp.

*Those manufacturers who participated in the SPI Monthly Polyols Report in 1988

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds) **

	Production	Sales & Captive Use				
Year		Total	Flexible Foam	Rigid Foam	Non-Foam	Export
1984	1,347	1,305	915	144	148	98
1985	1,391	1,407	1,014	133	141	119
1986	1,452	1,453	1,000	127	158	168
1987	1,626	1,653	1,045	144	188	276
1988	1,872	1,918	1,134	138	232	414

** Dry Weight Basis

Source: Quarterly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

POLYESTER POLYOLS

MANUFACTURERS*

Brinmont Chemicals, Inc.
Chemical Exchange Industries
Dow Chemical, U.S.A.
Freeman Chemical - Chardenol Division
Hercules, Inc.
Inolex Chemical Company
Mobay Chemical Corporation
Stepan Company
Sterling Engineered Products
Union Carbide Corporation
Uniroyal, Chemical Division
Witco Chemical

*Those manufacturers who participated in the Quarterly Polyester Polyols Report in 1988.

PRODUCTION AND SALES & CAPTIVE USE

(thousands of pounds) **

	Production		Sales & Captive Use	
Year	Aliphatic[1]	Aromatic[2]	Aliphatic[1]	Aromatic[2]
1984	26,185	NA	25,624	NA
1985	40,712	NA	40,223	NA
1986	46,764	NA	46,362	NA
1987	55,653	124,147	54,790	122,916
1988	57,855	144,559	56,843	143,076

[1] Excludes Polyesters for foam, includes Caprolactones
[2] Includes Rigid Foam
NA = Not Available
** Dry Weight Basis

Source: Quarterly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

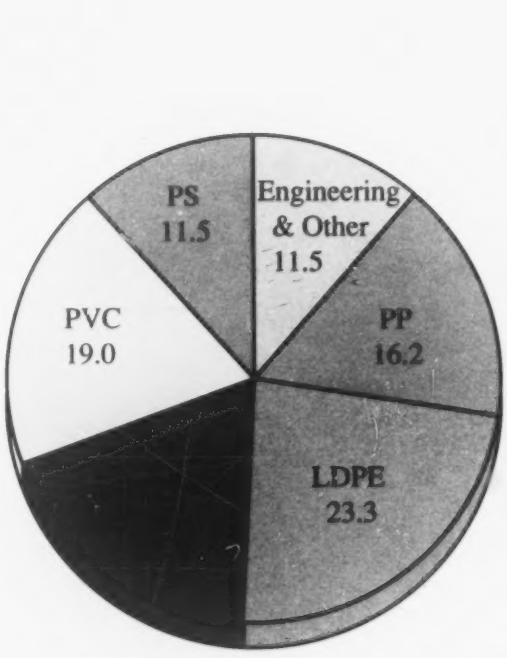
The Society of the Plastics Industry, Inc.

Thermoplastic Resins

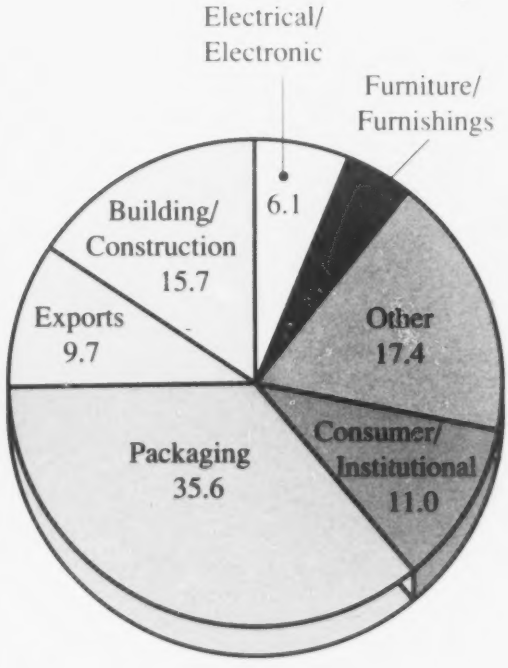
SUMMARY STATISTICS

Thermoplastic resins are plastics which are capable of being repeatedly softened by heat and hardened by cooling in their final form as finished articles.

1988 THERMOPLASTIC SALES & CAPTIVE USE



**1988
PERCENT
BY RESIN MATERIAL**



**1988
PERCENT
BY MAJOR MARKET**

NOTE: Includes data from reporting companies only.

Source: SPI Major Market Report, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

LATEX MATERIAL

Latex materials (sometimes referred to as emulsion polymers) are dispersions of the plastic polymer particles in water. Developed in the laboratory in the early 1930's, the first successful product was a synthetic rubber latex, commercialized during World War II to supplement the short supply of natural rubber latex.

A great variety and profusion of emulsions are now in commercial production. The most important of the plastic latexes are copolymers of styrene and butadiene, homopolymers and copolymers of vinyl acetate, acrylates, and vinyl chloride, as well as emulsions of polyvinyl chloride, and other specialties. Other co-monomers used include fumarate, maleate, and ethylene.

The non-plastic synthetic rubber latices, excluded from SPI statistics, are elastomers categorized as Styrene/Butadiene (high butadiene), Polybutadiene, Acrylonitrile/Butadiene, Chloroprene, and Butyl. There is a significant amount of inter-product competition, particularly among the plastic types, and further there is competition with the synthetic and natural rubber latices which historically have been used.

The major end-uses for these plastic latex materials lie in four areas: (1) Adhesives - primarily in the packaging, construction, and wood products areas; (2) Coatings - primarily as a vehicle in waterbased paints; (3) Paper - primarily as a clay coatings binder, but also used for saturating; and (4) Textiles - primarily as fabric finishes, sizes, back coats, and in fabric lamination and non-woven fiber bonding.

The emulsions and compounds are generally sold or used in relatively small batches (drums, tank trucks, and tank cars), and in many applications the emulsions are tailor-made to the end-use. There are thousands of end-users, some of whom polymerize for themselves, some of whom buy compounded material.

Each product sold has some unique characteristic desired in the end-use. For example, some adhesive resins should impart water resistance, fabric resins should be hard or soft depending on the type desired, and coatings resins should have good tint retention properties.

As a class these plastic emulsions have gained wide acceptance in the above mentioned end-uses for one or more of the following reasons:

- Water base (will meet the requirements of air pollution controls and regulations)
- Ease of clean-up
- Good adhesion to various substrates
- High pigment binding capacity
- Abrasion resistance and flexibility
- Uniform quality as compared with natural binders
- Good supply picture as compared with many of the natural binders
- Relative low cost versus binding efficiency
- Compatibility with existing technology and processes

STYRENE BUTADIENE & OTHER STYRENE BASED LATEXES

Significant producers are: Dow, General Tire & Rubber, Goodyear, W.R. Grace, Morton Industries, Reichhold Chemicals and Union Chemical.

PRODUCTION AND SALES & CAPTIVE USE
(thousands of pounds)

		SALES & CAPTIVE USE*				
Year	Production	Paper Treating	Textile Treating	Carpet Backing	All Other	Total
1984	745,109	24,400	15,483	315,811	393,302	748,996
1985	736,163	39,064	17,026	304,370	429,609	790,069
1986	823,305	55,722	20,438	315,581	475,572	867,313
1987	929,364	46,256	16,480	364,371	543,200	970,307
1988	956,311	29,584	11,343	379,156	574,635	994,718

* Data may not be comparable due to variations in participation

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

ABS AND SAN

MANUFACTURERS*

B.F. Goodrich Chemical Co.
Dow Chemical U.S.A.
General Electric Plastics Co.
Monsanto Company
W.R. Grace & Co.

*Those companies who participated in the SPI Monthly Statistical Report in 1988

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

	PRODUCTION		SALES & CAPTIVE USE	
YEAR	ABS	SAN	ABS	SAN
1978	1,134	120	1,118	121
1979	1,191	124	1,183	126
1980	920	111	916	103
1981	916	107	900	105
1982	740	91	737	85
1983	NA	93	NA	91
1984	1,128	99	1,098	88
1985	1,028	87	1,016	84
1986	1,092	92	1,080	87
1987	1,175	126	1,208	127
1988	1,277	148	1,279	146
Average Annual Growth				
1978-1988	1.3%	2.0%	1.1%	1.9%

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

ABS AND SAN

DISTRIBUTION OF ABS AND SAN BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	267	269	285	*	314
Packaging	13	*	5	*	3
Building and Construction	*	134	133	*	147
Electrical/Electronic	269	241	261	*	*
Furniture and Furnishings	*	*	*	*	*
Consumer and Institutional	*	*	*	*	259
Industrial/Machinery	*	*	*	*	*
Adhesives/Inks/Coatings	*	*	*	*	*
All Other	638	456	484	1,136	702
Exports	*	*	*	199	*
Total	**1,187**	**1,100**	**1,168**	**1,335**	**1425**

* Included in All Other

TYPICAL APPLICATIONS

ABS		SAN	
Household appliances	Business machines	Automotive trim	Boat hulls
Telephones	Refrigerator liners	Marine instruments	Solar collectors
Bath tubs	Sporting goods	Tractor components	Swimming pool components
Automotive trim			

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

ENGINEERING THERMOPLASTIC RESINS

Engineering resins are characterized by a combination of high ratings for mechanical, thermal, electrical, and chemical properties. Fillers such as glass, carbon, metallic oxides, metallic powders, calcium carbonate, and silica products, and reinforcements such as fibrous glass, carbon, and other inorganic and organic fibers are added to improve these properties.

The following resins are generally considered to be included in the category of engineering resins: fluoropolymers; polyimides and polyamide-imides; modified polyphenylene oxide; polyphenylene sulfide; thermoplastic polyester resin; polycarbonate; polysulfone; and acetal. Other materials which may be used in similiar applications such as ABS, SAN, and nylon are mentioned elsewhere in Facts & Figures. Fluoropolymers, likewise, are mentioned elsewhere.

TYPICAL APPLICATIONS

Acetal (AC)	Fasteners, knobs, bushings, bearings, faucets, valves, seat belt components, conveyor belts, zippers, disposable lighter bodies.
Fluoropolymers	Wire & cable jacketing, nonstick coatings, bearing pads, laminates.
Polycarbonate (PCO)	Microwave cookware, filter housings, bottles, lamp housings, drapery fixtures, safety glazing, nameplates, food processor bowls.
Polyphenylene Sulfide (PPS)	Pumps, hair dryers, small cooking appliances, automotive components.
Thermoplastic Polyester (TP)	Lighting, microwave cookware, bearings, beverage bottles, food containers, auto grilles, switches.
Polysulfone (PSO)	Food processing equipment, circuit boards, camera and watch cases, purification devices, connectors.
Modified Polyphenylene Oxide(PPO)	Personal computers, auto instrument panels, wheel covers, pump housings, radomes, fuse boxes, TV cabinetry.
Polyimide (PI)	Printed wiring boards, gears, electric motors, radomes, bearings.
Polyamide-imide (PAI)	Seals, valve train components, jet engine components, transmissions.

ENGINEERING THERMOPLASTIC RESINS

MANUFACTURING

KNOWN MANUFACTURERS	AC	PCO	PPS	TP	PSO	PPO	PI	PAI	FLUORO-POLYMERS
Allied				X					
Amoco Chemical					X		X	X	
Ausimont									X
BASF Corp.				X					
Dow Chemical		X							
DuPont	X			X			X		X
Eastman Chemical				X					
General Electric		X		X		X	X		
Goodyear				X					
Hoechst Celanese	X			X					
ICI Americas				X					X
Mobay Chemical		X							
Pennwalt Corp.									X
Phillips Petroleum			X						

PRODUCTION AND SALES & CAPTIVE USE[1]

(in millions of pounds and dollars)

YEAR	PRODUCTION	SALES & CAPTIVE USE	COMPOUND GROWTH RATE OF SALES & CAPTIVE USE	
1978	648	639	1978-1988	7.3%
1979	729	709	1983-1988	11.1%
1980	673	645	1984-1985	- 6.0%
1981	676	633	1985-1986	0.1%
1982	569	596	1986-1987	13.9%
1983	731	781	1987-1988	37.7%
1984	878	892		
1985	834	839		
1986	877	840		
1987	1,036	957		
1988	1,342	1,318		

DISTRIBUTION BY MAJOR MARKET[1]

(in millions of pounds)

MAJOR MARKET	1983	1984	1985	1986	1987	1988
Transportation	123	136	140	*	*	*
Packaging	2	2	14	15	18	22
Building & Construction	76	101	79	84	82	*
Electrical/Electronic	275	305	250	236	*	*
Consumer/Institutional	82	90	28	31	63	91
Industrial/Machinery	75	88	37	43	37	45
Other	26	70	88	244	541	883
Exports	122	100	203	187	215	276
Total	**781**	**892**	**839**	**840**	**956**	**1,318**

Source: SPI Committee on Resin Statistics as compiled by Ernst & Whinney

[1] Excludes Thermoplastic Polyester resins

* Included in other

HIGH DENSITY POLYETHYLENE

MANUFACTURERS*

Allied Chemical Co.
Amoco Chemical Corp.
Cain Chemical Co.
Chevron Chemical Co.
Dow Chemical U.S.A.
Exxon Chemical Americas
Himont U.S.A.
Hoechst Celanese
Mobil Chemical Co.
Phillips Chemical Co.
Quantum Chemical Corp.
Soltex Polymers
Union Carbide Corp.

* Those manufacturers who participated in the SPI Monthly Statistical Report in 1988.

	CAPACITY	UTILIZATION RATE (%)
1978	4,895	85.8
1979	5,323	94.1
1980	5,921	74.4
1981	5,995	78.3
1982	6,439	76.5
1983	6,888	82.6
1984	7,341	82.9
1985	7,408	90.1
1986	7,301	98.4
1987	7,997	99.9
1988	8,530	98.5

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1978	4,201	4,165
1979	5,010	4,893
1980	4,405	4,394
1981	4,695	4,683
1982	4,928	5,024
1983	5,691	5,707
1984	6,085	5,949
1985	6,671	6,651
1986	7,182	7,028
1987	7,995	8,155
1988	8,400	8,084
Compound Growth Rate		
1978-1988	7.2%	6.8%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

HIGH DENSITY POLYETHYLENE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1984	1985	1986	1987	1988
Film (12 mils & below)	371	437	497	650	736
Sheet (over 12 mils)	121	140	177	231	282
Injection molding	1,191	1,538	1,550	1,780	1,658
Wire & cable	123	113	119	106	125
Extrusion coating	NA	NA	NA	NA	NA
Blow molding	2,079	2,245	2,400	2,884	3,002
Pipe & conduit	473	478	444	593	537
Other extruded products	45	36	50	61	87
All other uses	850	787	866	967	1,008
Total	**5,253**	**5,774**	**6,103**	**7,272**	**7,435**

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as complied by Ernst & Whinney.

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	*	183	232	213	145
Packaging	2,954	3,355	3,560	4,325	4,731
Building and Construction	513	546	522	775	830
Electrical/Electronic	149	153	147	138	135
Furniture and Furnishings	*	46	*	*	*
Consumer and Institutional	488	507	783	896	659
Industrial/Machinery	161	141	132	159	161
Adhesives/Inks/Coatings	*	--	*	*	25
All Other	988	843	728	766	749
Exports	696	877	924	883	649
Total	**5,949**	**6,651**	**7,028**	**8,155**	**8,084**

*Included in All Other

TYPICAL APPLICATIONS

Grocery bags	Florist tissue	55-gal. drums
Bottles	Cables	Shipping containers
Agricultural tanks	Gasoline tanks	Seating

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

HIGH DENSITY POLYETHYLENE

SELECTED END-USES

(in millions of pounds)

	1984	1985	1986	1987	1988
FILM	**361**	**461**	**491**	**648**	**731**
Millinery/merchandising bags	168	154	173	224	166
Food packaging	76	121	NA	137	115
All other	117	186	318	287	450
INJECTION MOLDING	**1,129**	**1,460**	**1,562**	**1,771**	**1,653**
Industrial and shipping pails[1]	324	375	433	483	436
Housewares[2]	105	116	166	188	192
Crates and totes[3]	112	179	156	192	218
Toys	63	68	66	52	39
Aerosol overcaps, caps, closures	91	89	70	90	117
Food tubs or containers	238	245	176	271	306
All other	196	388	495	495	345
BLOW MOLDING	**2,027**	**2,188**	**2,406**	**2,878**	**3,011**
Liquid food bottles	687	750	802	886	863
Household chemicals	657	724	813	1,033	965
Industrial drums	163	154	171	219	221
Pharmaceuticals, cosmetics & toiletries	113	NA	174	233	219
All other	407	560	446	507	743
ROTOMOLDING	NA	NA	NA	NA	NA
PIPE AND CONDUIT	**469**	**456**	**453**	**592**	**538**
Corrugated	138	103	143	162	108
Gas distribution	126	134	120	171	161
All other	205	219	190	259	269

NA = Not Available

[1] 5 gallons or less

[2] Includes household pails

[3] Includes beverage cases

Source: SPI Committee on Resin Statistics as compiled by Ernst & Whinney

LOW DENSITY POLYETHYLENE [1]

MANUFACTURERS*

Chevron Chemical Co.
Dow Chemical U.S.A.
DuPont
Eastman Chemical Co.
Exxon Chemical Americas
Mobil Chemical Co.
Quantum Chemical Corp.
Rexene Corp.
Soltex
Union Carbide Corp.
Westlake Polymers

*Those manufacturers who participated in the SPI monthly report in 1988

	CAPACITY	UTILIZATION RATE (%)
1978	8,003	88.9
1979	7,977	97.7
1980	8,471	86.1
1981	9,761	78.8
1982	9,361	80.2
1983	8,655	93.0
1984	9,491	88.6
1985	9,973	89.2
1986	10,086	88.3
1987	10,491	91.5
1988	11,479	90.6

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1978	7,111	7,147
1979	7,793	7,815
1980	7,291	7,467
1981	7,693	7,516
1982	7,503	7,687
1983	8,041	8,045
1984	8,413	8,416
1985	8,899	8,790
1986	8,903	8,799
1987	9,599	9,611
1988	10,397	10,177
Compound Growth Rate		
1978-1988	3.6%	3.6%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

[1] Includes data for Linear Low Density Polyethylene

LOW DENSITY POLYETHYLENE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1984	1985	1986	1987	1988
Film (12 mils & below)	4,689	4,777	4,787	5,234	5,514
Sheet (over 12 mils)	NA	NA	NA	NA	NA
Injection molding	612	583	574	697	758
Wire & cable	368	337	336	337	386
Extrusion coating	640	649	678	768	769
Blow molding	43	47	39	54	76
Pipe & conduit	27	28	32	48	63
Other extruded products	95	103	112	133	180
All other uses	968	1,136	1,301 *	1,338 *	1,525 *
Total	**7,442**	**7,660**	**7,859**	**8,609**	**9,271**

*Includes resellers and compounders

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	*	*	*	*	92
Packaging	5,393	5,469	5,605	6,161	5,929
Building and Construction	313	327	213	377	341
Electrical/Electronic	430	403	421	420	*
Furniture and Furnishings	4	37	71	41	48
Consumer and Institutional	666	468	507	610	866
Industrial/Machinery	*	*	*	*	272
Adhesives/Inks/Coatings	67	111	231	337	393
All Other	569	844	812	662	1,330
Exports	974	1,131	939	1,003	906
Total	**8,416**	**8,790**	**8,799**	**9,611**	**10,177**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Stretch wrap
Diaper liners
Household cling wrap
Squeeze bottles
Housewares
Lids
Closures
Pipe
Toys

LOW DENSITY POLYETHYLENE

SELECTED END-USES

(in millions of pounds)

	1984	1985	1986	1987	1988
PACKAGING FILM	**2,955**	**3,060**	**3,027**	**3,389**	**3,394**
Food Packaging	**874**	**970**	**980**	**945**	**1,133**
Produce	74	156	165	278	228
Bakery	243	292	356	370	378
All other	557	522	459	297	527
Non-Food Packaging	**1,705**	**1,756**	**1,674**	**1,929**	**1,721**
Industrial liners	949	833	696	712	564
Shipping sacks	219	253	262	351	287
All other	537	670	716	866	870
Pallet Shrink Film	**72**	*	**98**	*	*
All Other Shrink Film	**69**	**334**	**33**	**215**	**202**
Stretch Film	**235**	*	**243**	**300**	**338**
Non-Packaging Film	**1,640**	**1,687**	**1,723**	**1,801**	**2,190**
Trash bags	902	1,125	976	994	1,060
Construction and agriculture	194	123	118	230	226
Disposable diapers	NA	NA	134	201	196
All other	544	439	495	376	708
INJECTION MOLDING	**555**	**551**	**581**	**694**	**761**
Lids	140	124	148	194	241
Toys and novelties	23	17	31	28	9
Housewares	223	192	221	271	265
All other	169	218	181	201	246
EXTRUSION COATING	**637**	**593**	**708**	**768**	**777**
Paperboard	384	300	367	443	373
All other	253	293	341	325	404
WIRE AND CABLE	**NA**	**NA**	**338**	**337**	**386**
ROTOMOLDING RESINS	**56**			**157**	**162**

NA = Not available

* in all other shrink film

Source: SPI, Committee on Resin Statistics as compiled by Ernst & Whinney

NYLON

MANUFACTURERS*

Allied Chemical Co.
ATOCHEM Inc.
BASF Corp.
Belding Chemical Industries
Custom Resins, div. Bemis Co.
DuPont
Emser Industries
Hoechst Celanese
Mobay Corp.
Monsanto Company
Nylon Corp. of America
Shakespeare Co.
Wellman, Inc.

* Those manufacturers who participated in the SPI monthly report in 1988.

	CAPACITY	UTILIZATION RATE (%)
1978	369	74.5
1979	410	79.8
1980	428	64.0
1981	442	70.6
1982	429	53.1
1983	431	74.5
1984	511	77.5
1985	553	72.2
1986	509	91.4
1987	548	92.5
1988	614	92.2

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1978	275	278
1979	327	315
1980	274	271
1981	312	288
1982	228	247
1983	321	329
1984	396	389
1985	399	403
1986	465	443
1987	507	499
1988	566	574
Compound Growth Rate		
1978-1988	7.5%	7.5%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

NYLON

DOMESTIC CONSUMPTION BY END-USE

(in thousands of pounds)

END-USE	1984	1985	1986	1987	1988
Automotive and Truck	147,500	166,232	167,741	158,945	166,470
Electrical and Electronic[1]	45,247	42,286	46,996	58,826	61,967
Appliances	6,752	7,559	6,254	7,722	8,482
Film and Coating	43,014	41,698	46,459	52,763	66,998
Wire and Cable	20,913	21,093	22,269	27,288	26,064
Monofilament	15,283	16,006	20,753	19,924	25,930
Consumer[2]	19,547	20,930	24,604	30,381	27,563
Industrial/Machinery	34,111	31,931	26,600	30,314	35,750
Others	30,978	30,739	41,761	53,070	75,656
Total	**363,345**	**378,474**	**403,437**	**439,233**	**494,880**

[1]Includes electrical and electronic applications not assignable to automotive and truck or appliance markets

[2]Includes such items as housewares, brushes, combs, sporting goods, cameras and toys

Source: SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	156	180	192	164	164
Packaging	38	*	*	51	77
Building and Construction	*	*	*	*	26
Electrical/Electronic	73	67	71	94	82
Furniture and Furnishings	6	5	6	10	32
Consumer and Institutional	*	*	31	36	31
Industrial/Machinery	38	32	32	32	37
Adhesives/Inks/Coatings	*	*	*	*	5
All Other	52	95	72	53	40
Exports	26	24	39	59	80
Total	**389**	**403**	**443**	**499**	**574**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Electrical connectors
Fender extensions
Brush bristles
Auto components
Wire jackets
Power tool housings
Fishing line
Food packaging
Emission cannisters
Cooking bags
Sutures
Lawn/Garden equipment

POLYPROPYLENE

MANUFACTURERS*

Amoco Chemical Corp.
Aristech Chemical Co.
Eastman Chemical Products, Inc.
Exxon Chemical Co.
Fina Oil & Chemical
Genesis Polymers
Himont U.S.A.
Huntsman Chemical Corp.
Phillips Chemical Company
Rexene Corp.
Quantum Chemical Corp.
Shell Chemical Company
Soltex Polymer Corp.

* Those manufacturers who participated in the SPI monthly report in 1988.

	CAPACITY	UTILIZATION RATE (%)
1978	4,605	66.8
1979	5,035	76.3
1980	5,194	70.2
1981	5,056	78.2
1982	5,088	68.3
1983	5,272	84.1
1984	5,625	87.8
1985	5,800	88.6
1986	6,162	94.3
1987	6,865	96.9
1988	7,985	91.1

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1978	3,074	3,055
1979	3,841	3,894
1980	3,648	3,714
1981	3,955	3,888
1982	3,477	3,623
1983	4,434	4,464
1984	4,940	4,816
1985	5,139	5,275
1986	5,812	5,824
1987	6,647	6,720
1988	7,274	7,088
Compound Growth Rate		
1978-1988	9.0%	8.8%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

POLYPROPYLENE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1984	1985	1986	1987	1988
Injection molding, total	1,290	1,274	1,289	1,647	1,710
Appliances	121	114	127	141	146
Consumer products	292	310	311	430	418
Rigid packaging	360	387	430	527	607
Transportation	316	340	308	324	313
All other injection molding	201	123	113	225	226
Blow molding	105	105	106	114	132
Film (10 mils & below)	401	389	498	559	586
Sheet	52	44	39	82	126
Other extruded products (including wire & cable, pipe & conduit, and extrusion coating)	112	89	98	126	102
Fiber & filaments	1,338	1,433	1,516	1,750	1,841
All other uses	736	1,066	1,148	1,197	1,411
Total	**4,034**	**4,400**	**4,694**	**5,475**	**5,908**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	233	230	237	276	438
Packaging	901	1,000	1,128	1,450	1,632
Building and Construction	36	*	*	34	151
Electrical/Electronic	289	273	277	290	196
Furniture and Furnishings	1,123	1,119	1,103	1,255	1,218
Consumer and Institutional	624	621	732	966	1,102
Industrial /Machinery	*	11	*	*	84
Adhesives/Inks/Coatings	*	*	*	*	*
All Other	828	1,146	1,217	1,204	1,087
Exports	782	875	1,130	1,245	1,180
Total	**4,816**	**5,275**	**5,824**	**6,720**	**7,088**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Retort pouches	Fibers/Filaments	Battery cases	Filter plates	Straws
Tobacco wrap	Diaper coverstock	Carpet backing	Toys	Housewares
Bottles	Industrial fabrics	Threaded caps	Carpet face yarn	Syringes
Appliance parts	Pipes and profiles	Wire/Cable coating		Outdoor Furniture
Microwave oven containers			Automotive interior trim	

POLYSTYRENE

MANUFACTURERS*

A & E Plastics
American Polymers, Inc.
Amoco Chemical Corp.
ARCO Chemical Co.
BASF Corp.
Chevron Chemical Co.
Dart Container Corp.
Dow Chemical USA
Fina Oil & Chemical
Huntsman Chemical Corp.
Mobil Chemical Co.
Polysar, Inc.
Scott Polymers

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1988

	CAPACITY	UTILIZATION RATE (%)
1978	5,034	75.9
1979	5,201	77.0
1980	5,244	67.1
1981	5,161	70.2
1982	5,176	61.7
1983	5,189	68.7
1984	5,365	71.5
1985	5,158	78.6
1986	5,182	86.3
1987	5,221	91.6
1988	5,703	91.0

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1978	3,823	3,870
1979	4,005	3,997
1980	3,521	3,518
1981	3,621	3,604
1982	3,191	3,200
1983	3,567	3,606
1984	3,838	3,836
1985	4,054	4,108
1986	4,470	4,463
1987	4,780	4,860
1988	5,187	5,027
Compound Growth Rate		
1978-1988	3.1%	2.7%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

POLYSTYRENE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

END-USE	1984	1985	1986	1987	1988
Straight Polystyrene	1,959	2,078	2,260	2,526	2,690
Rubber-Modified Polystyrene	1,776	1,946	2,088	2,221	2,337
Total	**3,735**	**4,024**	**4,348**	**4,747**	**5,027**
Molding	1,436	1,403	1,540	1,857	1,849
Extrusion	1,468	1,737	1,966	2,105	2,180
Expandable Polystyrene Beads	487	521	497	523	586
All Other Uses	344	363	345	262	250
Total Domestic	**3,735**	**4,024**	**4,348**	**4,747**	**4,865**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

(in millions of pounds)

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	*	*	*	*	6
Packaging	1,540	1,292	1,360	1,421	1,726
Building and Construction	385	449	418	571	506
Electrical/Electronic	351	309	360	460	611
Furniture and Furnishings	26	47	47	40	127
Consumer and Institutional	754	1,090	1,296	1,668	1,306
Industrial/Machinery	*	*	*	--	--
Adhesives/Inks/Coatings	--	*	*	*	--
All Other	679	837	868	587	584
Exports	101	84	114	113	161
Total	**3,836**	**4,108**	**4,463**	**4,860**	**5,027**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Disposable Serviceware	Video cassettes	Business machines
Pallets	Appliance parts	Syringes
Trays	Roofing insulation	Egg cartons

POLYVINYL CHLORIDE

MANUFACTURERS*

Air Products & Chemicals
Borden Chemical Company
CertainTeed Products Corp.
Formosa Plastics
Georgia-Gulf Corp.
B.F. Goodrich Chemical Company
Goodyear Tire & Rubber Company
Keysor-Century Corp.
Shintech, Inc.
Occidental Chemical Co.
Vista Chemicals
Vygen

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1988

	CAPACITY	UTILIZATION RATE (%)	TYPICAL APPLICATIONS	
1978	6,302	90.8	Food wrap	Automotive seats
1979	7,093	86.3	Flooring	Medical Tubing
1980	7,126	76.8	Siding	Doors
1981	7,528	75.8	Pipe	Window frames
1982	7,389	72.1	Wall covering	Molding
1983	7,655	79.2	Coatings	Credit Cards
1984	8,317	81.3	Upholstery	Appliance housings
1985	8,355	81.1	Garden hose	Bottles
1986	8,036	90.3	Shower curtains	Apparel
1987	8,335	95.6	Wire/Cable Insulation	Toys
1988	8,906	93.8		

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1978	5,723	5,810
1979	6,119	6,138
1980	5,470	5,407
1981	5,707	5,601
1982	5,326	5,455
1983	6,066	6,152
1984	6,760	6,798
1985	6,772	6,720
1986	7,256	7,412
1987	7,971	8,081
1988	8,350	8,287
Compound Growth Rate		
1978-1988	3.9%	3.6%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

POLYVINYL CHLORIDE

DOMESTIC CONSUMPTION BY END-USE

(in millions of pounds)

	1984	1985	1986	1987	1988
Calendering, total	**720**	**690**	**716**	**779**	**856**
Flooring	173	161	163	188	205
Textile	91	71	79	110	128
All other calendering	456	458	474	481	523
Coating, total	**350**	**303**	**330**	**377**	**370**
Flooring	146	125	144	165	156
Textile & paper coating	107	93	97	110	108
Protective coatings	43	46	48	52	55
Adhesives & all other coatings	54	39	41	50	51
Extrusion, total	**4,330**	**4,481**	**4,898**	**5,296**	**5,248**
Wire & cable	411	455	419	464	433
Film & sheet	350	226	258	348	378
Rigid pipe & tubing (except fittings)	2,901	2,809	3,165	3,352	3,217
All other extrusions	668	991	530	504	529
Siding, siding accessories & mobile homes & skirts	NA	NA	526	628	691
Molding, total	**464**	**465**	**495**	**515**	**544**
Bottles	186	163	188	176	215
Sound records	75	68	54	NA	NA
Fittings (rigid pipe & tubing)	122	160	141	161	165
All other molding	81	74	112	178	164
Paste processes (except coating), total	**169**	**156**	**156**	**167**	**168**
Plastisol formulation	93	77	76	88	87
All other	76	79	80	79	81
Resellers & Compounders	**167**	**101**	**332**	**361**	**384**
All other uses	**220**	**233**	**115**	**155**	**200**
Grand Total	**6,420**	**6,429**	**7,042**	**7,650**	**7,770**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DISTRIBUTION BY MAJOR MARKET

MAJOR MARKET	1984	1985	1986	1987	1988
Transportation	163	141	149	*	153
Packaging	619	572	497	614	703
Building and Construction	4,134	4,198	4,711	5,056	4,920
Electrical/Electronic	398	479	478	524	559
Furniture and Furnishings	242	310	380	292	249
Consumer and Institutional	290	230	277	265	558
Industrial/Machinery	19	30	17	*	26
Adhesives/Inks/Coatings	108	89	83	110	136
All Other	447	379	450	790	466
Exports	378	292	370	430	517
Total	**6,798**	**6,720**	**7,412**	**8,081**	**8,287**

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

*Included in All Other NA = Not Available

POLYVINYL ACETATE

Polyvinyl acetate is produced by the emulsion polymerization of vinyl acetate to yield a water emulsion with a solids content of 50-55%. Commercial exploitation of this polymer began in the early 1930's, although its discovery dates from the early 1900's. Early production of the resin was primarily as a homopolymer, but more recently resin properties have been changed by including comonomers such as n-butyl acrylate, 2-ethylhexyl-acrylate, ethylene, dibutylmaleate, and dibutylfumarate. Because of the large number of polyvinyl acetate producers, the numerous copolymers included and the variety of physical forms, polyvinyl acetate production is reported to SPI in terms of vinyl acetate monomer sold to or used by the polymerizer.

Polyvinyl acetate resins are primarily used in aqueous emulsions and find utility in adhesives, paints, textile finishes, and paper coating applications. A typical example of a polyvinyl acetate emulsion is the "white glue" used in many homes and schools.

There are more than 40 producers of polyvinyl acetate, supplied with monomer by such companies as DuPont, Hoechst Celanese, Quantum Chemical Corp., USI Division, and Union Carbide Corp.

SALES AND CAPTIVE USE OF VINYL ACETATE MONOMER

FOR POLYVINYL ACETATE

(thousands of pounds)

Year	Emulsion Paint	Adhesives	Paper	Textile	Non-woven Binders	Others	Export	Total
1983	210,553	273,751	117,330	22,601	31,212	27,542	5,867	688,856
1984	203,282	275,002	119,528	25,924	30,896	28,767	6,976	690,375
1985	204,497	262,437	110,969	31,964	NA	58,185	6,124	674,176
1986	233,730	254,056	110,001	32,027	NA	56,340	3,964	690,118
1987	236,501	249,763	121,823	34,130	NA	59,961	6,596	708,774
1988	NA	NA	NA	NA	NA	NA	NA	NA

COMPOUND GROWTH RATE

TOTAL SALES & CAPTIVE USE

1984-1985	-0.1%
1985-1986	2.4%
1986-1987	2.7%

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

OTHER VINYL RESINS

Vinyl resins included in this category are polyvinyl butyral, polyvinyl formal, and polyvinylidene chloride and their respective copolymers containing at least 50% of the base resin.

Polyvinyl butyral and polyvinyl formal are prepared by reacting polyvinyl alcohol with butyraldhyde or formaldehyde in the presence of a strong mineral acid. There are many grades of these products in use, differing in degree of hydroxyl substitution and molecular weight. The largest end of polyvinyl butyral is as the adhesive film in the lamination of auto safety glass. The major use of polyvinyl formal is in magnet wire coatings.

Polyvinylidene chloride is prepared by suspension or emulsion polymerization of vinylidene chloride. It finds major application as a film or as a coating on flexible substrates for packaging food products where oxygen impermeability and oil resistance are important.

Producers of these vinyl resins include Dow, DuPont, W.R. Grace, Monsanto, Morton Industries, Rohm and Haas, and Unocal Corp.

PRODUCTION AND SALES & CAPTIVE USE

(thousands of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1983	185,558	177,844
1984	187,209	186,619
1985	189,699	191,437
1986	194,924	180,357
1987	212,314	203,643
1988	221,693	208,059

GROWTH RATE OF SALES & CAPTIVE USE

1984-1985	2.6%
1985-1986	-5.8%
1986-1987	12.9%
1987-1988	2.2%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Whinney

DOMESTIC SALES & USE

SELECTED THERMOPLASTICS BY PROCESS GRADE

(millions of pounds)

MATERIAL/YEAR	TOTAL	INJECTION MOLDING	EXTRUSION	BLOW MOLDING	OTHER
Grand Total*					
1983	26,546	5,778	13,407	2,620	4,741
1984	29,007	5,849	14,918	2,948	5,292
1985	30,407	6,052	15,526	3,182	5,647
1986	32,538	NA	NA	NA	NA
1987	33,626	NA	NA	NA	NA
1988	38,437	NA	NA	NA	NA
LD Polyethylene					
1983	7,127	657	5,628	42	800
1984	7,442	612	5,819	43	968
1985	7,660	583	5,894	47	1,136
1986	7,859	575	6,487	39	758
1987	8,609	697	7,110	54	748
1988	9,271	758	7,524	76	913
Growth Rate					
1983-1988	5.3%	2.8%	6.0%	12.6%	2.6%
HD Polyethylene					
1983	4,706	1,188	1,076	1,808	634
1984	5,253	1,191	1,133	2,079	850
1985	5,774	1,538	1,204	2,245	787
1986	6,103	1,550	1,275	2,400	878
1987	7,272	1,780	1,641	2,884	967
1988	7,435	1,658	1,767	3,002	1,008
Growth Rate					
1983-1988	9.6%	7.0%	10.4%	10.7%	9.7%
Polypropylene					
1983	3,664	1,232	1,724	90	618
1984	4,034	1,290	1,903	105	736
1985	4,400	1,274	1,955	105	1,066
1986	4,694	1,289	2,152	106	1,147
1987	5,475	1,647	2,517	114	1,197
1988	5,908	1,710	2,654	132	1,412
Growth Rate					
1983-1988	10.0%	6.8%	9.0%	7.9%	17.3%
ABS*					
1983	900	560	145	---	195
1984	1,000	600	150	---	250
1985	900	575	125	---	200
1986	1,080	NA	NA	---	NA
1987	1,208	NA	NA	---	NA
1988	1,279	NA	NA	---	NA
Growth Rate					
1983-1988	7.3%	NA	NA	---	NA

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

* = Not comparable, reporting changes in 1986 NA = Not Available ª ABS estimated 1983-1985

DOMESTIC SALES & USE

SELECTED THERMOPLASTICS BY PROCESS GRADE (Cont'd)

(millions of pounds)

MATERIAL/YEAR	TOTAL	INJECTION MOLDING	EXTRUSION	BLOW MOLDING	OTHER
Polystyrene					
1983	3,529	1,516	1,238	---------	775
1984	3,735	1,436	1,468	---------	831
1985	4,024	1,403	1,737	---------	884
1986	4,348	1,540	1,966	---------	842
1987	4,747	1,857	2,105	---------	785
1988	4,865	1,849	2,180	---------	836
Growth Rate					
1983-1988	6.6%	4.0%	12.0%	---------	1.6%
Nylon					
1983	305	198	85	---------	22
1984	363	243	95	---------	25
1985	378	251	100	---------	27
1986	403	266	112	---------	25
1987	439	267	131	---------	41
1988	495	293	148	---------	54
Growth Rate					
1983-1988	10.1%	8.1%	11.8%	---------	17.9%
Thermoplastic Folyester[b]					
1983	697	163	15	514	5
1984	760	200	20	535	5
1985	842	190	25	622	5
1986	1,009	NA	NA	NA	NA
1987	1,226	NA	NA	NA	NA
1988	1,414	NA	NA	NA	NA
Growth Rate					
1983-1988	15.2%	NA	NA	NA	NA
P V C					
1983	5,618	264	3,496	166	1,692
1984	6,420	277	4,330	186	1,627
1985	6,429	228	4,481	163	1,557
1986	7,042	306	4,899	188	1,649
1987	7,650	339	5,296	176	1,839
1988	7,770	329	5,248	215	1,978
Growth Rate					
1983-1988	6.7%	4.5%	8.4%	5.3%	3.1%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as compiled by Ernst & Whinney

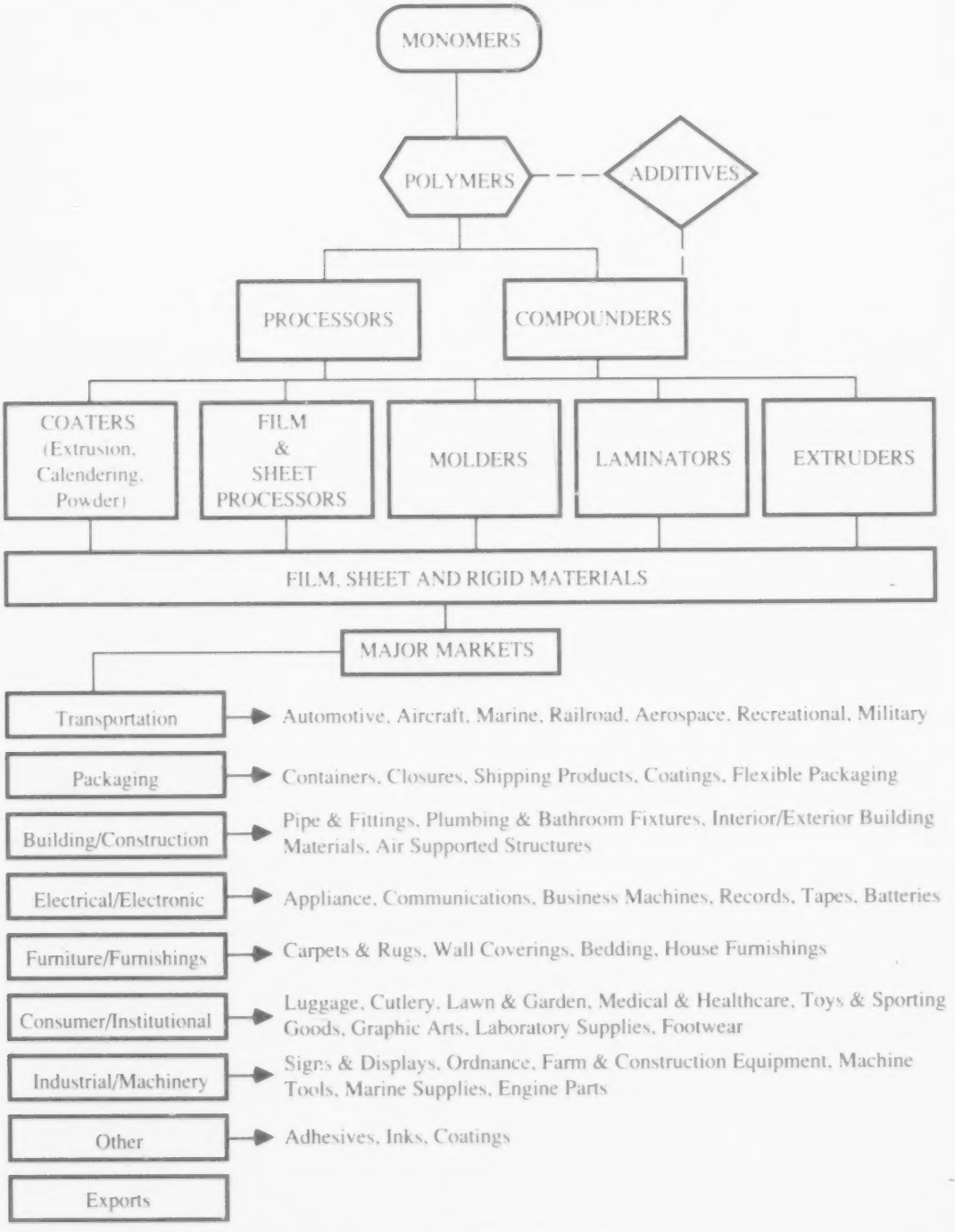
NA = Not Avalable. [b]Thermoplastic Polyester estimated 1983-1985.

The Society of the Plastics Industry, Inc.

Fabricated Plastic Products

FLOW CHART:

FROM RAW MATERIAL TO FINISHED PRODUCT



Source: SPI Committee on Resin Statistics, Major Markets Manual

COMPOSITES

Composites (also known as reinforced plastics) consist of a reinforcing agent and a plastic resin. Reinforcing agents include materials such as fiberglass (the most common), aramid, carbon, graphite and boron. The major plastic resin systems used are unsaturated polyester (the most common), epoxies, silicons, vinyl esters and various thermoplastic resins. Other components include fillers and a variety of additives which are also frequently added in the manufacturing process.

The fundamental characteristics of composites include lightweight, high strength-to-weight ratio, nonconductivity, corrosion-resistance and dimensional stability. In addition, composites provide considerable flexibility in design and the ability to consolidate parts. These benefits allow manufacturers to select the right combination for specific applications in every major market segment.

The composites industry enjoys a high level of technical activity due to the engineered nature of its end uses, and the relatively high value-added nature of the finished product. The search for new applications is vigorous, while new levels of performance in existing uses are continually being upgraded.

New resins and fabrication techniques are accelerating the acceptance and growth of composites. The development of new grades of engineered reinforced thermoplastics (RTP's), is also contributing to the growth of the composites industry. Over the past few years, new thermoplastic resin systems with superior resistance to high temperatures and improved surface characteristics have made possible the introduction of new product forms such as long fiber compounds, moldable or stampable sheets, pultrusion profiles, and filament winding.

In the past few years, the need for lightweight structural materials that meet strength, stiffness, and other mechanical property requirements for high performance applications, have prompted major developments in the aircraft/aerospace, construction, consumer, electrical, land transportation and marine markets. A few examples are:

Aircraft/Aerospace: The structure and interiors of both military and commercial planes are using increasing amounts of composite materials. Their light weight, moldability and versatile nature have prompted continued research and development in this industry resulting in growing replacement of the traditional metal parts by composites.

Consumer: The sports equipment market has led the way in the hybridization of carbon and glass to get the proper stiffness and weight in skis, ski poles, tennis racquets, fishing rods and golf club shafts.

Land Transportation: Composites are being used in automobiles, mobile homes, buses, and trucks. Applications can be found in body panels, front ends, bumpers and the interior dashboards. The light weight, moldability and corrosion-resistant features of composites add to the durability of the vehicle.

Marine: In the marine market, carbon/glass hybrids have allowed hull redesign from a solid laminate to a core/skin construction for lighter weight. Carbon provides the stiffness while glass provides the necessary strength.

PLASTIC COMPOSITES SHIPMENTS BY MARKET

(thermoset & thermoplastic resins)
(in millions of pounds)*

MARKETS	1984	1985	1986	1987[1]	1988[2]	1989[3]
Aircraft/Aerospace/Military	29	32	37	36	40	42
Appliances/Business Equipment	123	133	137	141	148	158
Construction	430	445	456	506	497	497
Consumer Products	143	142	149	167	170	181
Corrosion-Resistant Equipment	310	295	291	329	349	361
Electrical/Electronic	189	191	201	214	229	233
Marine	309	335	340	413	458	453
Land Transportation	540	563	585	656	695	710
Miscellaneous	80	82	83	75	80	82
Total	**2,153**	**2,218**	**2,279**	**2,537**	**2,666**	**2,717**

* Includes reinforcements & fillers [1]Revision [2]Estimate [3]Forecast

Source: SPI Composites Institute

VINYL SIDING & SOFFIT

Vinyl Siding is used mainly in the construction of exterior building walls, both for new construction and retrofit. Rigid polyvinyl chloride (PVC) homopolymer is compounded (blended) with a variety of auxiliary materials such as plasticizers, stabilizers, lubricants, pigments, etc., prior to being extruded into a wall siding product. The soffit, or underside of any structural component such as the eaves, is usually made of similar PVC material.

The Vinyl Siding Institute, a division of the SPI, sponsors a statistical program with its member companies as participants. Data is collected covering U.S. shipments of vinyl siding and soffit reported in "number of squares", which are units of measure common in the building and construction industry. One square equals 100 square feet of siding or enough to cover an area ten feet by ten feet.

PARTICIPATING VSI PRODUCERS 1988

Alcan Building Products
Alcoa Building Products/HC Products
Alsco
Alside, Inc.
Bird, Inc.
BPCO
CertainTeed Corp.
Crane Plastics Co. (VIPCO)
Daymond
Elixir Industries
Gold Bond Building Products
Heartland Building Products (Div. of Daymond)
Homestead of New England (New England Plastics)
Master Shield, Inc.
Mastic
Mikron Industries
Mitten Vinyl, Inc.
Sauder Industries, Ltd.
Variform
Vytec Corp.
Wolverine Technologies, Inc.

U.S. SHIPMENTS OF VINYL SIDING & SOFFIT

	Number of Squares*	Percent Change
1986	12,397,916	
1987	15,615,091	+ 26.0
1988	16,511,279	+ 5.7

Source: SPI Vinyl Siding Institute

* Believed to represent more than ninety percent of total U.S. Shipments.

PLASTIC BOTTLES

SHIPMENTS

(in millions of units)

BY MARKET	1985[R]	1986[R]	1987[R]	1988[I]
Household Chemicals	4,213	4,812	5,302	5,539
Industrial Chemical	391	433	400	428
Automotive & Marine	2,180	2,455	2,700	2,847
Toiletries & Cosmetics	2,582	2,530	2,889	2,982
Medicinal & Health	3,095	3,522	4,113	4,343
Food				
Milk	5,001	5,057	5,235	5,369
Other food	1,238	1,622	2,233	2,743
Beverages				
Carbonated Soft Drinks	5,430	6,600	7,970	9,070
Other beverages	1,780	2,399	3,260	3,842
Other	1,417	1,411	1,425	1,439
Total	**27,327**	**30,841**	**35,527**	**38,602**

EXPLANATION OF TERMS

Household Chemicals - Bleach, dishwashing, laundry, and other detergents; fabric softeners; bowl and drain cleaners; dry cleansers; floor care products; soaps (including medicated); window cleaners; air fresheners; household pesticides and garden chemicals; household adhesives; waxes and polishes (including car polish); car wax, wax and polish remover, etc.

Industrial, Agricultural and Specialty Chemicals - Agricultural, industrial, and institutional chemical and cleaning products; photographic chemicals; battery acid; paint and varnish supplies, etc.

Toiletries and Cosmetics - shampoos and other hair grooming products; talcs and powders; hand, face, and body lotions and ointments; shaving preparations; bath products; perfumes, toilet water, and colognes; personal deodorant, etc.

Medicinal and Health - Oral antiseptics and mouthwashes; laxatives; pharmaceutical lotions, creams, and ointments; pain relievers; vitamins; rubbing alcohols; antacids, etc.

Food and Beverages - Milk, carbonated beverages; noncarbonated beverages such as juices, water, cider, etc.; distilled spirits and other alcoholic beverages; edible oil; and all other food items.

Automotive and Marine - Antifreeze; motor oil; lubricants; defrosters; windshield cleaners; hydraulic fluids; additives, etc.

SHIPMENTS

(in millions of pounds)

BY MARKET	1985[R]	1986[R]	1987[R]	1988[I]
LD Polyethylene	47	54	47	44
HD Polyethylene	2,150	2,365	2,587	2,722
Polyvinyl Chloride	163	204	214	223
Polypropylene	105	113	119	128
Polyethylene Terephthalate	621	754	881	1,038
Polystyrene & Other	45	51	53	58
Total	**3,131**	**3,541**	**3,901**	**4,213**

[I] = Estimate [R] = Revised

Source: U.S. Department of Commerce; Census & ITA

Processing and Machinery

PROCESSING METHODS

INJECTION MOLDING

Injection molding is the principal method of forming thermoplastic materials. Modifications of the injection process are sometimes used for thermosetting plastics.

In injection molding, plastic material is put into a hopper which feeds into a heating chamber. A plunger pushes the plastic through this long heating chamber where the material is softened to a fluid state. At the end of this chamber there is a nozzle which abuts firmly against an opening into a cool, closed mold. The fluid plastic is forced at high pressure through this nozzle into the cold mold. As soon as the plastic cools to a solid state, the mold opens and the finished plastic is ejected from the press.

The problem with injection molding of thermosetting materials is that, under heat, these plastics will first soften, then harden to an infusible state. Thus it is essential that no softened thermosetting material in the heating chamber be allowed to remain there long enough to set. Jet molding, offset molding and molding using a screw-type machine overcome this problem by liquefying the thermosetting plastic material just as it goes through the injection nozzle into the mold, but not before.

BLOW MOLDING

Blow molding is a method of forming used with thermoplastic materials.

Basically, blow molding consists of stretching and then hardening a plastic against a mold. There are two general methods of doing this type of thermoplastic molding: the direct method and the indirect method, encompassing several variations of each.

In the direct method, a glob of molten thermoplastic material is formed into the rough shape of the desired finished product. This shape is then inserted in a female mold and air blown into the plastic, as into a balloon, to force it against the sides of the mold. The formed material is then cooled before removal from the mold.

In the indirect method, a thermoplastic sheet or special shape is first heated, then clamped between a die and cover. Air pressure forced between the plastic and the cover forces the material into contact with the die, which has the contour desired in the finished product. The plastic is cooled before removal from contact with the die.

THERMOFORMING

Thermoforming of plastic sheet has developed rapidly in recent years. Basically, this process consists of heating thermoplastic sheet to a formable plastic state and then applying air and/or mechanical assists to shape it to the contours of a mold.

Air pressure may range from almost zero to several hundred psi *. Up to approximately 14 psi (atmospheric pressure), the pressure is obtained by evacuating the space between the sheet and the mold in order to utilize this atmospheric pressure. This range, known as *vacuum forming*, will give satisfactory reproduction of the mold configuration in the majority of forming applications.

* psi= pounds per square inch.

TRANSFER MOLDING

Transfer molding is most generally used for thermosetting plastics.

This method is like compression molding in that the plastic is cured into an infusible state in a mold under heat and pressure. It differs from compression molding in that the plastic is heated to a point of plasticity before it reaches the mold and is forced into a closed mold by means of an hydraulically-operated plunger.

Transfer molding was developed to facilitate the molding of intricate products with small deep holes or numerous metal inserts. The dry mold compound used in compression molding sometimes disturbs the position of the metal inserts and the pins which form the holes. The liquified plastic material in transfer molding flows around these metal parts without causing them to shift position.

REACTION INJECTION MOLDING

Reaction injection molding (RIM) is a relatively new processing technique that has rapidly taken its place alongside more traditional methods. Unlike liquid casting, the two liquid components, polyols and isocyanates, are mixed in a chamber at relatively low temperatures (75° - 140°) before injection into a closed mold. An exothermic reaction occurs and consequently RIM requires far less energy usage than any other injection molding system.

The three major types of polyurethane RIM systems are rigid structural foam, low-modulus elastomers, and high-modulus elastomers.

Reinforced RIM (R-RIM) consists in the addition of such materials as chopped or milled glass fiber to the polyurethane to enhance stiffness and to increase modulus thus expanding the range of applications.

COMPRESSION MOLDING

Compression molding is the most common method of forming thermosetting materials. It is not generally used for thermoplastics.

Compression molding is simply the squeezing of a material into a desired shape by application of heat and pressure to the material in a mold.

Plastic molding powder, mixed with such materials or fillers as woodflour and cellulose to strengthen or give other added qualities to the finished product, is put directly into the open mold cavity. The mold is then closed, pressing down on the plastic and causing it to flow throughout the mold. It is while the heated mold is closed that the thermosetting material undergoes a chemical change which permanently hardens it into the shape of the mold. The three compression molding factors -- pressure, temperature and time the mold is closed -- vary with the design of the finished article and the material being molded.

EXTRUSION

Extrusion molding is the method employed to form thermoplastic materials into continuous sheeting, film, tubes, rods, profile shapes, filaments, and to coat wire, cable and cord.

In extrusion, dry plastic material is first loaded into a hopper, then fed into a long heating chamber through which it is moved by the action of a continuously revolving screw. At the end of the heating chamber the molten plastic is forced out through a small opening or die with the shape desired in the finished product. As the plastic extrusion comes from the die, it is fed onto a conveyor belt where it is cooled, most frequently by blowers or by immersion in water.

In the case of wire and cable coating, the thermoplastic is extruded around a continuing length of wire or cable which, like the plastic, passes through the extruder die. The coated wire is wound on drums after cooling.

In producing wide film or sheeting, the plastic is extruded in the form of a tube. This tube may be split as it comes from the die and then stretched and thinned to the dimensions desired in the finished film.

In a different process, the extruded tubing is inflated as it comes from the die, the degree of inflation of the tubing regulating the thickness of the final film.

SHIPMENTS

INJECTION MOLDING MACHINERY

(in number of units)

CLAMP FORCE (Tons)	1984	1985	1986	1987	1988
0-199	666	543	339	372	355
200-299	612	447	309	326	392
300-399	507	371	295	293	349
400-499	506	423	329	350	388
500-599	94	109	66	95	120
600-749	169	181	126	140	171
750-1199	97	147	131	91	132
1200-1999	42	71	59	54	78
2000 and over	12	40	55	27	31
Grand Total	**2,705**	**2,332**	**1,709**	**1,748**	**2,016**

SINGLE SCREW EXTRUSION MACHINERY

(in number of units)

SCREW DIAMETER	1984	1985	1986	1987	1988
Up to But Not Including . . . . . 2"	184	156	172	154	149
2" Up to But Not Including . . . . . 2 1/2"	168	115	114	117	145
2 1/2" Up to But Not Including . . . . . 3"	267	235	212	223	259
3" Up to But Not Including . . . . . 4"	198	216	213	253	258
4" Up to But Not Including . . . . . 5 1/2"	181	140	134	159	172
5 1/2" Up to But Not Including . . . . . 7 1/2"	106	76	75	62	83
Includes 7 1/2" & Larger	12	16	5	14	20
Total	**1,116**	**954**	**925**	**982**	**1,086**

Note: Includes domestic shipments and exports
Source: SPI Machinery Division

DOLLAR SALES *

PLASTICS MACHINERY

(in millions of dollars)

MACHINE TYPE	1984	1985	1986	1987	1988
Injection Molding	457.0	376.0	315.0	257.1	292.5
Structural Foam	4.5	4.5	3.9	3.9	4.2
Extrusion, single screw	137.0	84.5	121.0	112.5	125.5
Extrusion multi screw	22.0	16.0	14.5	15.6	14.0
Blow Molding	105.0	65.0	80.0	70.0	120.0
Thermoforming	44.0	50.0	55.0	60.0	75.0
Reaction-Injection Molding	10.0	7.5	6.0	6.8	7.5
Compression	16.5	13.0	13.5	16.2	18.0
Expanded Bead	8.0	1.0	0.5	0.5	1.0
Transfer Molding	5.5	4.5	5.0	7.1	7.0
Total	**809.5**	**622.0**	**614.4**	**549.7**	**664.7**

* Includes exports, does not include imports

Source: Modern Plastics Magazine

Glossary

ADDITIVES FOR PLASTICS

ADDITIVE LUBRICANTS

These materials are added to plastics to assist flow in calendering, molding and extrusion by lubricating the metal surfaces in contact with the plastic. They also assist in knitting and wetting of the resin in mixing and milling operations. To be effective, lubricants must be compatible with the resins in which they are used, must not adversely affect the properties of end-products, and must be easily combined.

Examples: stearic acid, waxes, fatty acid esters, fatty acid amines.

ANTIOXIDANTS

They inhibit the oxidation of materials exposed to air or oxygen at normal or elevated temperatures. They are used in plastics which are subject to oxidative degradation, such as polyolefins, ABS, polystyrene, acetal and polyphenylene oxide.

Examples: alkylated phenols, amines, organic phosphites and phosphates, esters.

ANTISTATS

Chemicals which impart a slight to moderate degree of electrical conductivity to plastics compounds, thus preventing the accumulation of electrostatic charges on finished articles. They may be incorporated in the material before molding, or applied to their surfaces after molding. They function either by being inherently conductive or by absorbing moisture from the air.

Examples: quaternary ammonium compounds, anionics, amines.

BLOWING AGENTS (FOAMING AGENTS)

Substances which alone or in combination with other substances are capable of producing a cellular structure in a plastic or rubber mass. Thus, the term includes compressed gases which expand when pressure is released, soluble solids that leave pores when leached out, liquids that develop cells when they change to gases, and chemical agents that decompose or react under the influence of heat to form a gas.

Examples: azodicarbonamide, modified azos, OBSH, HTBA.

COLORANTS

Dyes or pigments which impart color to plastics. The dyes are synthetic or natural compounds of submicroscopic or molecular size, soluble in most common solvents, yielding perfectly transparent colors. The pigments are organic and inorganic substances with larger particle sizes and usually insoluble in the common solvents. Colorants are added to plastics by dry coloring (tumbling the colorant with the base or compounded resin); by extrusion coloring (extruding a dry colored mixture and chopping it into pellets to be reprocessed); by masterbatching; or by stirring colorants or dispersions thereof into liquid plastisols or resin systems.

Examples: titanium dioxide, iron oxides, anthraquinones, carbon black.

FLAME RETARDANTS

Materials that reduce the tendency of plastic articles to burn. They are usually incorporated as additives during compounding, but sometimes are applied to surfaces of finished articles.

Examples: antimony trioxide, chlorinated paraffins, bromophenols.

HEAT STABILIZERS

Agents used in compounding some plastics to assist in maintaining the physical and chemical properties of the compounded materials at suitable values throughout the processing and service life of the material and/or the parts made therefrom. They protect plastics from the effects of heat such as changes in color decrease in mechanical and electrical properties, and undesirable surface conditions.

Examples: lead, barium-cadmium, tin, calcium-zinc.

ORGANIC PEROXIDES

Thermally decomposable compounds which can initiate polymerization reactions and effect cross-linking upon decomposition. The rate of decomposition can be controlled by means of promoters or accelerators added to the system to increase the decomposition rate; or by inhibitors when it is desired to retard the decomposition.

Examples: MEK peroxide, benzoyl peroxide, alkyl peroxide, peresters.

PLASTICIZERS

Materials incorporated in a plastic or elastomer to increase its flexibility, workability or distensibility. Most plasticizers are nonvolatile organic liquids or low-melting point solids, which function by reducing the normal intermolecular forces in a resin thus permitting the macromolecules to slide over one another more freely.

Examples: adipates, azelates, trimellitates, DOP/DIOP/DIDP.

ULTRAVIOLET STABILIZERS (UV LIGHT ABSORBERS)

Chemical agents which absorb or screen out radiation beyond the violet end of the spectrum of visible radiations. Such radiation has sufficient energy to initiate reactions leading to the degradation of many plastics. These agents are often combined with other additives, e.g. heat stabilizers and antioxidants, with which they act in synergistic fashion.

Examples: benzophenones, benzotriazole, salicylates.

Source: Whittington's Dictionary of Plastics

DEFINITIONS OF RESINS

ACETAL

An engineering thermoplastic produced by the polymerization of purified formaldehyde [CH_2O] into both homopolymer and copolymer types. Typical applications are found in consumer products, automotive parts, and industrial machinery parts.

ACRYLICS

A family of thermoplastic resins of acrylic esters [$CH_2CHCOOR$] or methacrylic esters [$CH_2C(CH_3)COOR$]. The acrylates may be methyl, ethyl, butyl, or 2-ethylhexyl. Usual methacrylates are the methyl, ethyl, butyl, laural and stearyl. Typical applications are found in lighting fixtures, glazing and automotive parts.

ACRYLONITRILE BUTADIENE STYRENE

A class of thermoplastic terpolymers including a range of resins, all prepared with usually more than 50% styrene [$C_6H_5CHCH_2$] and varying amounts of acrylonitrile [CH_2CHCN] and butadiene [$CH_2CHCHCH_2$]. The three components are combined by a variety of methods involving polymerization, graft copolymerization, physical mixtures and combinations thereof. Typical applications are found in appliances, automotive parts, pipe, business machine and telephone components.

ALKYDS

Thermosetting unsaturated polyester resins produced by reacting an organic alcohol with an organic acid, dissolved in and reacted with unsaturated monomers such as styrene [$C_6H_5CHCH_2$], diallyl phthalate [$C_6H_4(COOCH_2CHCH_2)_2$], diacetone acrylamide [$CH_3COCH_2C(CH_3)_2CHCHCONH_2$] or vinyl toluene [$CH_3CHC_6H_4CH_3$]. Typical applications are found in electrical uses, automotive parts, and as coatings.

CELLULOSICS

A family of thermoplastic resins manufactured by chemical modification of cellulose [$(C_6H_{10}O_5)_n$]. Included are: *cellophane*--regenerated cellulose made by mixing cellulose xanthate [ROCSSH] with a dilute sodium hydroxide [NaOH] solution to form a viscose, then extruding the viscose into an acid bath for regeneration; *cellulose acetate*--an acetic acid ester [$CH_3COOC_6H_7$] of cellulose; *cellulose acetate butyrate*--a mixed ester produced by treating fibrous cellulose with butyric acid [$CH_3CH_2CH_2COOH$], butyric anhydride [$(CH_3CH_2CH_2CO)_2O$], acetic acid [CH_3COOH] and acetic anhydride [$(CH_3CO)_2O$] in the presence of sulfuric acid [H_2SO_4]; *cellulose propionate*-- formed by treating fibrous cellulose with propionic acid [$CH_3CH_2CO_2H$] and acetic acid and anhydrides in the presence of sulfuric acid; *cellulose nitrate*--made by treating fibrous cellulosic materials with a mixture of nitric [HNO_3] and sulfuric acids. Typical applications are found in packaging, consumer products, and automotive parts.

COUMARONE-INDENE

Thermoplastic resin obtained by heating mixtures of coumarone [C_8H_6O] and indene [$C_6H_4CH_2CHCH$] with sulfuric acid [H_2SO_4] to promote polymerization. These resins have no commercial applications when used alone. They are used primarily as processing aids, extenders and plasticizers with other resins in asphalt floor tile.

DIALLYL PHTHALATE(DAP)

The term DAP is used both for the monomeric and polymeric forms. The monomer [$C_6H_4(COOCH_2CHCH_2)_2$] is used as a cross-linking agent in unsaturated polyester resins. As a polymer, it is used in the production of thermosetting molding powders, casting resins and laminates.

EPOXY

Thermosetting resins, that, in the uncured form, contain one or more reactive epoxide or oxirane groups.

These epoxide groups serve as cross-linking points in the subsequent curing step, in which the uncured epoxy is reacted with a curing agent or hardener. Cross-linking is accomplished through the epoxide groups as well as through hydroxyl groups that may be present. Most conventional unmodified expoxy resins are produced from epichlorohydrin (chloropropylene oxide) [CH_2OCHCH_2Cl] and bisphenol A[$(CH_3)_2C(C_6H_5OH)_2$]. The other types of epoxy resins are phenoxy resins, novolac resins, and cycloaliphatic resins. Epoxy resins are used as protective coatings, bonding adhesives, in building and construction, and electrical uses, plus many other uses.

FLUOROPOLYMERS

A family of thermoplastic resins analogous to polyethylene in which some of the hydrogen atoms attached to the carbon chain are replaced by fluorine or fluorinated alkyl groups. In some cases, other halogens such as chlorine are also part of the molecule. The most common commercial fluoropolymers are: *FEP* (fluorinated ethylene-propylene) from tetrafluoroethylene [C_2F_4] and hexafluoropropylene [C_3F_6]; *PTFE* (polytetrafluoroethylene) from the polymerization of tetrafluoroethylene and ethylene [C_2H_4]; *PFA* (perfluoro-alkoxy) from tetrafluoroethylene and perfluoropropyl vinyl ether [$C_3HC_2OF_3$]; *PCTFE* (polychlorotrifluoro-ethylene) from chlorotrifluoro-ethylene monomer [C_2F_3Cl]; *CTFE-VDF* (polychlorotrifluoroethylenevinylidene fluoride) from chlorotrifluoroethylene and vinylidene fluoride [$C_2H_2F_2$]; *E-CTFE* (polyethylene-chlorotrifluoroethylene) from chlorotrifluoroethylene and ethylene; *PVDF* (polyvinylidene fluoride) from vinylidene fluoride monomer; and, *PVF* (polyvinyl fluoride) from vinyl fluoride monomer [C_2H_3F]. Typical applications for fluoropolymers are found in electrical/electronic uses and pipe and chemical processing equipment.

MELAMINE-FORMALDEHYDE

Thermosetting resins formed by the condensation reaction of formaldehyde [HCHO] and melamine [$C_3N_3(NH_2)_3$]. The chemistry is analogous to that of urea-formaldehyde except that the three amino groups of melamine provide more possibilities for cross-linking, are more highly reactive, and all six hydrogen atoms of melamine will react, forming the hexamethyl compound. Typical applications are found in bonding and adhesives, coatings, and consumer products.

NITRILE RESINS

Thermoplastic resins composed of acrylonitrile [CH_2CHCN] along with comonomer such as acrylates, methacrylates, butadiene [$CH_2CHCHCH_2$] and styrene [$C_6H_5CHCH_2$]. Both straight copolymers and copolymers grafted onto elastomeric backbones are available. The unique property of these materials is outstanding resistance to passage of gases and water vapor, making them useful in packaging applications.

NYLON

A generic name for a family of long-chain polyamide engineering thermoplastics which have recurring amide groups [-CO-NH-] as an integral part of the main polymer chain. Nylons are synthesized from intermediates such as dicarboxylic acids, diamines, amino acids and lactams, and are identified by numbers denoting the number of carbon atoms in the polymer chain derived from specific constituents, those from the diamine being given first. The second number, if used, denotes the number of carbon atoms derived from a diacid. Commercial nylons are as follows: *nylon* 4 (polypyrrolidone)-a polymer of 2-pyrrolidone [$CH_2CH_2CH_2C(O)NH$]; *nylon* 6 (polycaprolactam)-made by the polycondensation of caprolactam[$CH_2(CH_2)_4NHCO$]; *nylon* 6/6-made by condensing hexamethylenediamine [$H_2N(CH_2)_6NH_2$] with adipic acid [$COOH(CH_2)_4COOH$]; *nylon* 6/10-made by condensing hexamethylenediamine with sebacic acid[$COOH(CH_2)_8COOH$]; *nylon* 6/12-made from hexamethylenediamine and a 12-carbon dibasic acid; *nylon* 11-produced by polycondensation of the monomer 11-amino-undecanoic acid [$NH_2CH_2(CH_2)_9COOH$]; *nylon* 12-made by the polymerization of laurolactam [$CH_2(CH_2)_{10}CO$]or cyclododecalactam, with 11 methylene units between the linking -NH-CO- groups in the polymer chain. Typical applications for nylons are found in automotive parts, electrical/electronic uses, and packaging.

PETROLEUM RESINS

Thermoplastic resins obtained from a variable mixture unsaturated monomers recovered as byproduct from cracked and distilled petroleum streams. They also contain indene [$C_6H_4CH_2CHCH$], which is copolymerized with a variety of other monomers including styrene [$C_6H_5CHCH_2$], vinyl toluene [$CH_2CHC_6H_4CH_3$], and methyl indene [$C_6H_4CH_2CH_2CHCH$]. Typical applications are found in adhesives, printing inks, rubber compounding, and surface coatings.

PHENOLIC

These thermosetting resins are credited with being the first commercialized wholly synthetic polymer or plastic. The basic raw materials are formaldehyde [HCHO] and phenol [C_6H_5OH], although almost any reactive phenol or aldehyde can be used. The phenols used commerically are phenol, cresols [$CH_3C_6H_4OH$], xylenols [$(CH_3)_2C_6H_3OH$], p-t-butylphenol [$C_4H_9C_6H_4OH$], p-phenylphenol [$C_6H_5C_6H_4OH$], bisphenols [$(C_6H_4OH)_2$], and resorcinol [$C_6H_4(OH)_2$]. The aldehydes used are formaldehyde and furfural [C_4H_3OCHO]. In the uncured and semi-cured condition, phenolic resins are used as adhesives, casting resins, potting compounds, and laminating resins. As molding powders, phenolic resins can found in electrical uses.

POLYAMIDE-IMIDE

Engineering thermoplastic resins produced by the condensation reaction of trimellitic anhydride [$OCC_6H_3C_2O_3$] and various aromatic diamines. Typical applications are found in aerospace, automotive and heavy equipment industries.

POLYARYLATES

Engineering thermoplastic resins produced by interfacial polymerization of an aqueous solution of the disodium salt of bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$] with phthalic acid chlorides [$C_6H_4(CO)_2Cl_2$] in methylene chloride (CH_2Cl_2]. The major use of polyarylates is in outdoor lighting.

POLYBUTYLENE

Thermoplastic resins produce via stereospecific Ziegler-Natta polymerization of butene-1 monomer [$CH_3CHCH_2CH_3$]. Typical applications are found in pipe and packaging film.

POLYCARBONATE

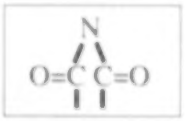
Engineering thermoplastic resins produced by (1) phosgenation of dihydric phenols, usually bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$], (2) ester exchange between diaryl carbonates and dihydric phenols, usually between diphenyl carbonate [$(C_6H_5O)_2CO$] and bisphenol A and (3) interfacial polycondensation of bisphenol A and phosgene [$COCl_2$]. Typical applications are found in glazing, appliances, and electrical uses.

POLYETHYLENE

A family of thermoplastic resins obtained by polymerizing the gas ethylene [C_2H_4]. Low molecular weight polymers of ethylene are fluids used as lubricants; medium weight polymers are waxes miscible with paraffin; and the high molecular weight polymers (i.e. over 6000) are the materials used in the plastics industry. Polymers with densities ranging from about .910 to .925 are called *low density*; those of densities from .926 to .940 are called *medium density*; and those from .941 to .965 and over are called *high density*. The low density types are polymerized at very high pressures and temperatures, and the high density types at relatively low temperatures and pressures. A relatively new type called linear low density polyethylene is manufactured through a variety of processes: gas phase, solution, slurry, or high pressure conversion. A high efficiency catalyst system aids in the polymerization of ethylene and allows for lower temperatures and pressures than those required in making conventional low density polyethylene. Copolymers of ethylene with vinyl acetate ethyl acrylate, and acrylic acid are commercially important. Major polyethylene applications can be found in packaging, housewares, toys and communications equipment.

POLYIMIDES

A family of thermoset and thermoplastic resins characterized by repeating imide linkages:



There are four types of aromatic polyimides: (1) condensation products made by the reaction pyromellitic dianhydride (PMDA) [$C_6H_2(C_2O_3)_2$] and aromatic diamines such as 4,4'-diaminodiphenyl ether [$(C_6H_4NH_2)_2O$]; (2) condensation products of 3,4,3',4'-benzophenone tetracarboxylic dianhydride (BTDA) [$(C_6H_3)_2CO(C_2O_3)_2$] and aromatic amines;(3) the reaction of BTDA and a diisocyanate such as 4,4'-methylene-bis(phenylisocyanate) [$OCNC_6H_4CH_2C_6H_4NCO$]; and, (4) a polyimide based on diaminophenylindane and a dicarboxylic andhydride such as carbonyldiphthalic anhydride [$OC_6H_3(CO)_2COC_6H_3(CO)_2$]. Thermoset polyimides are produced in condensation polymers that possess reactive terminal groups capable of subsequent cross-linking through an addition reaction. Typical applications for thermoplastic and thermosetting polyimides are transportation and electronics.

POLYPHENYLENE OXIDE, MODIFIED

Engineering thermoplastic resins produced by the oxidative coupling of 2, 6-dimethylphenol [$(CH_3)_2C_6H_3OH$] (xylenol), then blended with impact polystyrene. Typical applications are found in electrical/electronic uses, business machine parts, appliances, and automotive parts.

POLYPHENYLENE SULFIDE

Engineering thermoplastic resins produced by the reaction of p-dichlorobenzene [$C_6H_4Cl_2$] with sodium sulfide [Na_2S]. The major use for polyphenylene sulfide is in electrical/electronic parts and automotive parts.

POLYPROPYLENE

Thermoplastic resins made by polymerizing propylene [CH_2CHCH_3] and in the case of copolymers with monomers, with suitable catalysts, generally aluminum alkyl and titanium tetrachloride mixed with solvents. The monomer unit in polypropylene is asymmetric and can assume two regular geometric arrangements: isotactic, with all methyl groups aligned on the same side of the chain, or syndiotactic, with the methyl groups alternating. All other forms, where this positioning is random, are called atactic. Commerical polypropylene contains 90-97% crystalline or isotactic PP with the remainder being atactic. Most processes remove excess atactic PP. This by-product is used in adhesives, caulks, and cablefilling compounds. Major applications of commerical PP are found in packaging, automotive, appliance and carpeting markets.

POLYSTYRENE

High molecular weight thermoplastic resins produced generally by the free-radical polymerization of styrene monomer [$C_6H_5CHCH_2$] which can be initiated by heating alone but more effectively by heating in the presence of free-radical initiator (such as benzoyl peroxide [$(C_6H_5CO)_2O_2$]. Typical processing techniques are modified mass polymerization or solution polymerization, suspension polymerization, and expandable beads. Major markets for polystyrene are in consumer and institutional products, electrical/electronic uses, and building/construction.

POLYURETHANES

A large family of polymers based on the reaction product of an organic isocyanate with compounds containing a hydroxyl group. The commonly used isocyanates are toluene diisocyanate (TDI) [$CH_3C_6H_3(NCO)_2$], methylene diphenyl isocyanate (MDI) [$OCNC_6H_4CH_2C_6H_4NCO$], and polymeric isocyanates (PMDI), obtained by the phosgenation of polyamines derived from the condensation of aniline [$C_6H_5NH_2$] with formaldehyde (HCHO). Polyols (with hydroxyl groups) are macroglycols which are either polyester or polyether based. Polyurethane elastomers and resins take the form of liquid castings systems thermoplastic elastomers and resins, microcellular products, and millible gums. Typical applications are found in the automotive industry. Polyurethane foams are widely used in transportation, furniture, and construction markets.

POLYVINYL ACETATE (PVAc) & OTHER VINYLS

Polyvinyl acetate is a thermoplastic resin produced by the polymerization of vinyl acetate monomer [$CH_3COOCHCH_2$] in water producing an emulsion with a solids content of 50-55%. Most polyvinyl acetate emulsions contain co-monomers such as n-butyl acrylate, 2-ethyl hexyl acrylate, ethylene, dibutyl maleate and dibutyl fumarate. Polymerization of vinyl acetate with ethylene also can be used to produce solid vinyl acetate/ethylene copolymers with more than 50% vinyl acetate content. Polyvinyl alcohol (PVOH) is produced by methanolysis or hydrolysis of polyvinyl acetates. The reaction can be controlled to produce any degree of replacement of acetate groups. Co-polymers of replaced acetate groupings and other monomers such as ethylene and acrylate esters are commercially important. *Polyvinyl butyral* (PVB) - made by reacting PVOH with butyraldehyde [$CH_3(CH_2)_2CHO$]. *Polyvinyl formal* - made by condensing formaldehyde [HCHO] in presence of PVOH or by the simultaneous hydrolysis and acetylization of PVAc. *Polyvinylidene chloride* - made by the polymerization of 1,1-dichloroethylene [CH_2CCl_2]. Typical applications for the above resins are found in adhesives, paints, coatings and finishes, and packaging.

POLYVINYL CHLORIDE

Thermoplastic resins produced by the polymerization of the gas vinyl chloride [CH_2CHCl]. Under pressure, vinyl chloride becomes liquified and is polymerized by one of four basic processes: suspension, emulsion, bulk, and solution polymerization. The pure polymer is hard, brittle and difficult to process, but it becomes flexible when plasticizers are added. A special class of PVC resin of fine particle size, often called dispersion grade resin, can be dispersed in liquid plasticizers to form plastisols. The addition of a volatile diluent or a solvent to the plastisol produces an organosol. Copolymers with vinyl acetate, vinylidene chloride, and maleate and fumarate esters find commercial application. Major markets for PVC are in building/construction, packaging, consumer and institutional products, and electrical/electronic uses.

STYRENE ACRYLONITRILE

Thermoplastic copolymers of styrene [$C_6H_5CHCH_2$] and acrylonitrile [CH_2CHCN]. SAN resins are random, amorphous copolymers produced by emulsion, suspension, or continuous mass polymerization. Typical uses include automobile instrument lenses and housewares.

STYRENE BUTADIENE LATEXES & OTHER STYRENE COPOLYMERS

Styrene butadiene latexes usually have a resin content of about 50%. The styrene/butadiene ratio varies from 54:46 to 80:20. Most are carboxylated by the use of such acids as maleic [HOOCCHCHCOO], fumaric [HOOCCHCHCOOH], acrylic [$CH_2CHCOOH$], or methacrylic [$CH_2C(CH_3)COOH$]. Two types of *styrene-maleic anhydride* (SMA) [$(COCH)_2O$] are available: SMA copolymers, with and without rubber impact modifier (e.g. DYLARK®) and SMA terpolymer alloys (e.g. CADON®). *K-Resin* ® is a solid styrenebutadiene copolymer resin. Acrylic monomers are also used in conjunction with styrene (or styrene plus other monomers) to produce specialty resins. For example, there are transparent terpolymers of methyl methacrylate, butadiene, and styrene (MBS), and others of acrylonitrile, an acrylic monomer, and styrene (AAS). Ion-exchange resins or divinylbenzene-modified polystyrene are another variation. SB latexes are used in carpet backing and paper coatings. The other styrenics are used in paints, coatings, and floor polishes, plus many other uses.

SULFONE POLYMERS

A family of engineering thermoplastic resins characterized by the sulfone ([SO] group. *Polysulfone* is made by the reaction of the disodium salt of bisphenol A[(CH) C(C H OH)] with 4,4'-dichlorodiphenyl sulfone(4,4'-DCDPS [(C H Cl) SO]. *Polyethersulfone* is made by the reaction of 4,4'-DCDPS with potassium hydroxide [KOH]. *Polyphenylsulfone* is similar to the other sulfone polymers. Typical applications for sulfone polymers are found in electrical/electronic uses and automotive parts.

THERMOPLASTIC POLYESTER (SATURATED)

A family of polyesters in which the polyester backbones are saturated and hence unreactive. The most common commercial types are: PET (polyethylene terephthalate) produced by polycondensation of ethylene glycol [CH OHCH OH] with either dimethyl terephthalate (DMT) [C H (COOCH)] or terephtalic acid (TPA) [C H (COOH]; and PBT (polybutylene terephthalate) produced by the reation of DMT with 1,4 butanediol [NO(CH) OH]. Typical applications are found in packaging, automotive, electrical, and consumer markets.

UREA-FORMALDEHYDE

Formed by the condensation reaction of formaldehyde [HCHO] and urea [CO(NH)]. These thermoset resins are clear water-white syrups or white powered materials which can be dispersed in water to form colorless syrups. They cure at elevated temperatures with appropriate catalysts. Molding powders are made by adding fillers to the uncured syrups, forming a consistency suitable for compression and transfer molding. The liquid and dried resins find extensive used in laminates and chemically-resistant coatings. The molding compounds are formed into rigid electrical and decorative products.

UNSATURATED POLYESTER

Thermosetting resins made by the condensation reaction between difunctional acids and glycols. The resulting polymer is then dissolved in styrene [C H CHCH] or other vinyl unsaturated monomer. The structures of the acids and glycols used and their proportions, especially the ratio of the unsaturated versus the saturated acid, and the type and amount of monomer used, are all tailored for each resin to balance economy, processing characteristics, and performance properties. One common formulation is the reaction of maleic anhydride [(COCH) O], phthalic anhydride [C H (CO) O], and propylene glycol [CH CHOHCH OH]. Both dicyclopentadiene [(C H5)] and isophthalic acid [C H (COOH)] can be substituted for phthalic anhydride. Vinyl ester resins are linear reaction products of bisphenol A [(CH) C(C H OH)] and epichlorohydrin [CH OCHCH Cl] that are terminated with an unsaturated acid such as methacrylic acid [CH C(CH)COOH]. Typical applications are found in transportation, appliances, electrical, and construction markets.

Sources: *Chemical Economics Handbook, SRI International, Modern Plastics Encyclopedia Whittington's Dictionary, The Condensed Chemical Dictionary*

DEFINITIONS OF SELECTED PLASTICS PROPERTIES

ABLATION - The degradation and decomposition of a material caused by high heat friction.

ABRASION RESISTANCE - Ability to resist surface wear.

AGING - The effect, on materials, of exposure to an environment for an interval of time.

ARC RESISTANCE - The total time in seconds that intermittent arc may play across a plastic surface with rendering the surface conductive.

BLEEDING - The diffusion of color out of a plastic part into surrounding surface of part.

BLOCKING - The adhesion between touching layers of plastic, such as that which may develop under pressure during storage or use.

BLOOM - A visible exudation or efflorescence on the surface of a plastic; bloom can be caused by lubricant, plasticizer, etc.

BRITTLE POINT - The highest temperature at which an elastomer fractures in a prescribed impact test procedure.

BRITTLE TEMPERATURE - The lowest temperature at which a plastic material withstands given conditions without failure.

BUCKLING - Crimping of the fibers in a composite material, often occurring in glass-reinforced thermosets due to resin shrinkage during cure.

BULK DENSITY - The density of a molding material in loose form (granular, nodular, etc.) expressed as a ratio of weight to volume.

BULK FACTOR - The ratio of the volume of a molding compound or powdered plastic to the volume of the solid piece produced from it.

COEFFICIENT OF EXPANSION - The fractional change in dimension of a material for a unit change in temperature.

COEFFICIENT OF FRICTION - A measure of the resistance to sliding of one surface in contact with another surface.

COEFFICIENT OF LINEAR EXPANSION - A measure of the change in dimension of an object caused by a change in temperature; specifically measured by the increase in length of an object per unit degree in temperature.

COEFFICIENT OF THERMAL EXPANSION - The change in volume per unit volume produced by a one degree rise in temperature.

COMPRESSIVE STRENGTH - The ability of a material to resist a force that tends to crush.

Glossary

CORROSION RESISTANCE - The ability of a material to withstand contact with ambient natural factors or those of a particular artificially created atmosphere.

CRACK - An actual separation of molded material, visible on opposite surfaces of the part, and extending through the thickness; a fracture.

CRAZING - Fine cracks which may extend in a network on or under the surface of a plastic material.

CREEP - The change in dimension of a plastic under load over a period of time, not including the initial instantaneous elastic deformation.

CROSS-LINKING - Applied to polymer molecules, the setting-up of chemical links between the molecular chains. When extensive, as in most thermosetting resins, cross-linking makes one infusible supermolecule of all the chains.

DEFLECTION TEMPERATURE UNDER LOAD - The temperature at which a simple beam has deflected a given amount under load (formerly called heat distortion temperature).

DEFORMATION - Any change of form or shape in a body; the linear change of dimension of a body in a given direction produced by the action of external forces.

DEGRADATION - A deleterious change in the chemical structure of a plastic.

DETERIORATION - A permanent change in the physical properties of a plastic evidenced by impairment of these properties.

DIMENSIONAL STABILITY - Ability of a plastic part to retain the precise shape to which it was molded, cast, or otherwise fabricated.

DISCOLORATION - Any change from an initial color possessed by a plastic; a lack of uniformity in color where color should be uniform over the whole area of a plastic object.

ELASTICITY - That property of plastics materials by virtue of which they tend to recover their original size and shape after deformation.

ELASTOMERIC - The property of a material which at room temperature can be stretched under low stress to at least twice its original length and, upon immediate release of the stress, will return with force to its approximate original length.

ELECTRICAL STRENGTH [DIELECTRIC STRENGTH] - That property of an insulating material which enables it to withstand electric stress; the highest electric stress which an insulating material can withstand for a specificed time without the occurrence of electrical breakdown by any path through its bulk.

ELONGATION - Deformation caused by stretch; the fractional increase in length of a material stressed in tension.

ENVIRONMENTAL STRESS CRACKING - The susceptibility of a thermoplastic resin to crack or craze when in the presence of surface active agents or other environments.

EXTENSIBILITY - The ability of a material to extend or elongate upon application of sufficient force, expressed as a percent of the original length.

EXUDATION - The formation in liquid form a plasticizer on the surface of a plasticized resin.

FADING - Any lightening of an initial color possessed by a plastic; measured by accelerating the process by subjecting the plastic to high intensity ultraviolet rays of approximately the same wave length as those found in sunlight.

FATIGUE - The failure or decay of mechanical properties after repeated applications of stress.

FLAMMABILITY - Measure of the extent to which a material will support combustion.

FLEX LIFE - The time of heat-aging that an insulating material can withstand before failure when bent around a specific radius (used to evaluate thermal endurance).

FLEXURAL STRENGTH - The resistance of a material to being broken by bending stresses.

FLOW MARKS - Wavy surface appearance of an object molded from thermoplastic resins, caused by improper flow of the resin into the mold.

GEL POINT - The stage at which a liquid begins to exhibit pseudoelastic properties. Also known as "gel-time."

GLASS TRANSITION TEMPERATURE - The center of the temperature range in which a noncrystalline solid changes from being glass-brittle to being viscous.

GLOSS - Brightness or luster of a plastic resulting from a smooth surface.

HAZE - Cloudy appearance within, or on the surface, of a plastic.

HEAT DISTORTION POINT - The temperature at which a standard test bar deflects under a stated load.

HEAT RESISTANCE - The property or ability of plastics and elastomers to resist the deteriorating effects of elevated temperatures.

HYDROLYSIS - Chemical decomposition of a substance involving the addition of water.

HYDROPHILIC - Capable of absorbing water.

HYDROPHOBIC - Capable of repelling water.

HYGROSCOPIC - Capable of adsorbing and retaining atmospheric moisture.

IMPACT STRENGTH - The ability of a material to withstand shock loading.

LACK OF FILLOUT - An area, occurring usually at the edge of a laminated plastic, where the reinforcement has not been wetted with resin.

MELT INDEX - The amount in grams, of a thermoplastic resin which can be forced through a 0.0825 inch orifice when subjected to 2160 grams force in 10 minutes.

MELTING POINT - The temperature at which a resin changes from a solid to a liquid.

MELT STRENGTH - The strength of a plastic while in the molten state.

MIGRATION - The transfer of a material from a plastic body to other contacting solids.

MOISTURE ABSORPTION - The pick-up of water vapor from air by a material. It relates only to vapor withdrawn from the air by a material and must be distinguished from water absorption, which is the gain in weight due to the take-up of water by immersion.

MOTTLE - The desired or accidental mixture of colors or shades of a color giving more or less distinct or complicated patterns or specks, spots, or streaks of color; any irregular imperfections on the surface.

NECKING - The localized reduction in cross-section which may occur in a material under tensile stress.

OPALESCENCE - The limited clarity of vision through a sheet of transparent plastic at any angle, because of diffusion within or on the surface of the plastic.

OPTICAL DISTORTION - Any apparent alteration of the geometric pattern of an object when seen through a plastic or as reflection from a plastic surface.

OXIDATION - The chemical reaction involving the process of combining with oxygen to form an oxide; the deterioration of an adhesive film due to atmospheric exposure; the break down of a hot melt adhesive due to prolonged heating and oxide formation.

PIT - Small regular or irregular crater in the surface of a plastic, usually with width approximately of the same order of magnitude as its depth.

PLASTICITY - A property of plastics which allows the material to be deformed continuously and permanently without rupture upon the application of a force that exceeds the yield value of the material. (The opposite of "elasticity.").

SHEARING - Breaking caused by the action of equal and opposed forces, located in the same plane.

SPECIFIC GRAVITY - The ratio of the weight of any volume of a substance to the weight of an equal volume of another substance taken as standard at a constant or stated temperature. Solids and liquids are usually compared.

SPECIFIC HEAT - The quantity of heat required to raise the temperature of a unit mass of a substance one (1) degree under specified conditions.

STRESS-CRACK- External or internal cracks in a plastic caused by tensile stresses less than that of its short-time mechanical strength.

SWEATING - Exudation of small drops of liquid, usually a plasticizer or softener, on the surface of a plastic part.

Glossary

SWELL - A dimensional increase caused by exposure to liquids and/or vapors.

TEAR RESISTANCE - The force required to tear completely across a notched specimen tested according to prescribed procedures, expressed in pounds per inch of specimen thickness.

TENSILE STRENGTH OR STRESS - The maximum tensile load per unit area of original cross section, within the gage boundaries, sustained by the specimen during a tension test.

THERMAL CONDUCTIVITY -Ability of a material to conduct heat.

THERMOELASTICITY - Rubber-like elasticity exhibited by a rigid plastic and resulting from an increase of temperature.

THERMOPLASTICITY - The ability of material to be deformed without breaking with a relatively fast flow, when (at a suitable temperature) this material is properly stressed.

TUNNELING - A condition occuring in incompletely bonded laminates, characterized by release of longitudinal portions of the substrate and deformation of these portions to form tunnel-like structures.

VISCOSITY- The property of resistance to flow exhibited within the body of a material, expressed in terms of relationship between applied shearing stress and resulting rate of strain in shear.

WEATHERING - The exposure of plastics outdoors.

Other Sources of Plastics Information

Business Consulting Groups and Publishers

Business Communications Co., Inc. - 25 Van Zant St., Norwalk, CT 06855 - 203/853-4266
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Arthur D. Little, Inc. - 25 Acorn Park, Cambridge, MA 02140 - 617/864-5770
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Market Search, Inc. - 2727 Holland Sylvania Rd. Suite A, Toledo, OH 43615 - 419/535-7899
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Skeist Laboratories, Inc. - 375 Route 10, Whippany, NJ 07981 - 201/515-2020
Springborn Group - 20 Springborn Ctr., Enfield, CT 06082 - 203/749-8371
SRI International - 333 Ravenswood Ave., Menlo Park, CA 94025 - 415/326-6200
The Target Group - 1000 Harston Lane, Philadelphia, PA 19118 - 215/233-4083
Technomic Consultants, Inc. - 300 South Riverside Plaza, Chicago, IL 60606 - 312/876-0004
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Phillip Townsend Associates - P.O. Box 90327, Houston, TX 77090 - 713/873-8733

Government Publications

Annual Survey of Manufacturers - Bureau of the Census
Census of Manufacturers - Bureau of the Census
Current Industrial Reports - Bureau of the Census
Foreign Trade Reports - FT 135 (imports), FT 410 (exports) - Bureau of the Census
Guide to Census Bureau Data Files and Special Tabulations - Bureau of the Census
Guide to Foreign Trade Statistics - Bureau of the Census
Producer Price Indexes - Bureau of Labor Statistics
Standard Industrial Classification Manual - Office of Management and Budget
Statistical Abstract of the U.S. - Department of Commerce
Statistical Services of the U.S. Government - Office Management and Budget
Synthetic Organic Chemicals - International Trade Commission
U.S. Industrial Outlook - Department of Commerce

Newspapers

Chemical Marketing Reporter - 100 Church St., New York, NY 10007 - 212/732-9820
Journal of Commerce - 110 Wall St., New York, NY 10005 - 212/425-1616
Rubber & Plastics News - 1725 Merrinan Rd., Suite 300, Akron, OH 44313 - 216/836-9180

Trade Associations & Professional Organizations

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International Isocyanate Institute - 119 Cherry Hill Rd., Parsipanny, NJ 07054 - 201/263-7517
National Paint & Coatings Assn. - 1500 Rhode Island Ave. NW, Washington, D.C. 20005 - 202/462-6272
Polyurethane Manufacturers Assn. - 1500 K St., NW, Washington, D.C. 20005 - 202/682-1338
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Society of the Plastics Industry-Canada - 1262 Don Mills Rd., Suite 104, Don Mills, Ontario M3B2W7 - 416/449-3444
Synthetic Organic Chemical Manufacturers Assn. - 1330 Connecticut Ave., NW, Suite 300, Washington, D.C. - 202/659-0060

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Chemical & Engineering News - 1155 16th St., NW, Washington, D.C. 20036 - 202/872-4600
Chemical Week - 1221 Ave. of the Americas, New York, NY 10020 - 212/512-2292
Material Engineering - 1100 Superior Ave., Cleveland, OH 44114 - 216/696-7000
Modern Plastics - 1221 Ave. of the Americas, New York, NY 10020 - 212/512-6243
Packaging Digest - 122 East 42nd St., New York, NY 10168 - 212/867-9191
Plastics Compounding - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Connection - P.O. Box 814, Amherst, MA 01004 - 413/549-5020
Plastics Design Forum - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
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MONTHLY STATISTICAL REPORT
THE SOCIETY OF PLASTICS INDUSTRY, INC.
(In thousands of pounds, dry weight basis)

THERMOSET RESINS — DECEMBER 1980

RESIN KIND & USE	SALES & CAPTIVE USE						PRODUCTION					
	DECEMBER			YEAR-TO-DATE			DECEMBER			YEAR-TO-DATE		
	1980	1979	% Change	1980	1979	% Change	1980	1979	% Change	1980	1979	% Change
EPOXY (UNMODIFIED) RESINS, TOTAL	30,709	25,639	+19.8	318,756R	331,970	-4.0	26,491	24,829	+6.7	315,039R	361,077	-12.8
Total Exports	3,732	3,496	+6.8	35,547	35,730	-0.5						
Total Domestic	26,977	22,143	+12.8	283,209R	296,240	-4.4						
Bonding & Adhesives	1,931	1,431	+34.9	17,742R	17,454	+1.7						
Flooring, Paving & Exposed Aggregate	1,886	1,481	+27.3	19,231R	19,583	-1.8						
Protective Coatings	13,417	9,648	+39.1	137,308R	146,137	-6.0						
Fiber Reinforced Laminates & Composites	5,164	4,785	+7.9	62,690R	60,268	+4.0						
Tooling, Casting & Molding Resins	2,749	2,417	+13.7	25,664R	30,940	-17.1						
All Other Uses	1,830	2,381	-23.1	20,574R	21,858	-5.9						
POLYESTER (UNSATURATED) RESINS, TOTAL	75,749	76,020	-0.4	921,169R	1,151,581	-20.0	76,524	78,733	-2.8	925,947R	1,147,174	-19.3
General Purpose Resins							66,503	68,719	-3.2	805,583R	1,010,750	-20.3
Fire Retardant Resins							2,757	2,550	+8.1	28,739	32,035	-10.3
Chemical Resistant Resins							7,264	7,464	-2.7	91,625 R	104,389	-12.2
Isophthalic Resins							3,830	4,917	-22.1	52,437R	63,158	-17.0
All Other Resins	903	841	+7.4	11,254	14,250	-22.5	3,434	2,547	+34.8	39,188R	41,231	-5.0
Total Exports	74,846	75,179	-0.4	909,915R	1,137,061	-20.0						
Total Domestic	59,069	58,428	+1.1	709,229R	905,949	-21.7						
Reinforced Plastics, Total	15,777	16,751	-5.8	200,686R	231,112	-13.2						
Non-Reinforced Plastics, Total	719,992	666,312	+8.1	7,467,466R	7,814,845	-4.4						
LOW-DENSITY POLYETHYLENE 0.940 & BELOW, TOTAL	109,576	65,000	+68.6	1,147,442R	897,575	+27.8	675,113	650,391	+3.8	7,290,727R	7,793,233	-6.4
Total Exports	610,416	65,000	+68.6	1,147,442R	897,575	+27.8						
Total Domestic	610,416	601,312	+1.5	6,320,024R	6,917,270	-8.6						
Film (12 Mils & Below)	392,242	383,360	+2.3	4,003,749	4,363,250	-8.2						
Sheet (Over 12 Mils)	921	1,930	-52.3	18,176	25,825	-29.6						
Injection Molding	36,555	57,100	-36.5	519,294R	649,975	-20.1						
Wire & Cable	20,042	34,572	-42.0	335,403	424,139	-20.9						
Extrusion Coating	38,772	41,001	+9.2	517,406R	539,098	-4.0						
Blow Molding	5,129	4,786	+7.2	65,453R	59,524	+10.0						
Pipe & Conduit	2,660	2,293	+16.0	21,768R	32,718	-33.5						
Other Extruded Products	4,244	5,140	-17.4	56,018R	79,614	-29.6						
All Other Uses	93,851	71,130	+31.9	782,756R	743,127	+5.3						
HIGH-DENSITY POLYETHYLENE ABOVE 0.940, TOTAL	413,377	394,243	+4.9	4,393,038R	4,893,243	-10.2						
Total Exports	61,114	54,188	+12.8	526,438R	608,654	-13.5	407,174	419,864	-3.0	4,405,021	5,009,839	-12.1
Total Domestic	352,263	340,055	+3.8	3,866,600	4,284,589	-9.8						
Film (12 Mils & bBelow)	21,622	14,714	+46.9	201,086	212,399	-5.3						
Sheet (Over 12 Mils)	7,921	4,541	+74.4	54,937	65,520	-16.2						
Injection Molding	89,601	84,541	+6.0	937,964	1,073,724	-12.6						
Wire & Cable	6,285	7,074	-11.2	105,555	125,921	-16.2						
Extrusion Coating	3,213	2,038	+57.7	27,565	30,242	-8.9						
Blow Molding	138,168	139,521	-1.0	1,573,140	1,724,076	-8.8						
Pipe & conduit	30,468	25,135	+21.2	368,352	400,395	-8.0						
Other Extruded Products	1,703	2,120	-19.7	24,250	18,931	+28.1						
All Other Uses	53,282	60,371	-11.7	573,751	633,381	-9.4						

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1990 edition

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THE SOCIETY OF THE PLASTICS INDUSTRY, INC.

The Society of the Plastics Industry, Inc. is a member-run association dedicated to promoting and protecting continuing growth for the plastics industry in the United States. The Society represents more than 2,000 member companies.

Incorporated in 1937, SPI has grown with the dynamic industry it represents. SPI's 27 operating units and more than 200 committees have membership drawn from all segments of the industry - processors, resin and adjuvant suppliers, plastics distributors, machinery builders, and moldmakers. The Society serves as a federation of semi-autonomous, interrelated groups with a strong, common interest in the overall health of the plastics industry.

SPI serves as the "industry spokesman." It identifies and provides positive responses to misinformation and to potentially harmful regulations, bills, or court decisions by mobilizing pertinent facts and carrying out programs for timely and forceful action. At the same time, SPI works to prevent such damaging situations from occuring by building a positive understanding of the industry. The Society's service committees provide liaison with government agencies, code and regulatory groups, and many other associations.

SPI sponsors research projects in areas such as resource recovery, combustibility, and worker safety, at major private research organizations. The Society conducts numerous information programs, providing literature, surveys, reports, newsletters, and handbooks for industry and public use.

SPI sponsors one of the largest trade shows in the United States - the National Plastics Exposition, held every three years. The most recent show was held in June 1988 at McCormick Place in Chicago.

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SPI'S COMMITTEE ON RESIN STATISTICS

The SPI Committee on Resin Statistics is composed of 100 representatives from plastics resin producing companies, trade publications, industry-related professional organizations, and various agencies of the Federal Government. All members of the Committee are quite knowledgeable of the rapidly growing plastics industry and have a special interest in the development of marketing and economic data.

The Committee is responsible for the development and maintenance of a monthly report on the major plastics materials. This report shows monthly and cumulative data on production and sales & use (including captive operations) with percent change from the previous year. It is the only detailed monthly report on plastics materials now available. There are over one hundred producers participating in the monthly program and they are believed to represent about 95% of total U.S. plastics production. Many of the materials covered reflect 100% industry coverage. The data is compiled by Ernst & Young, a nationally renowned Independent Public Accountants.

The Committee is actively involved with the various departments of the Federal Government (International Trade Commission, Department of Commerce, Bureau of the Census, Bureau of Labor Statistics, etc.) assisting them in the development and improvement of the plastics segments of their reports.

The Committee is also responsible for monitoring all resin data which appear in FACTS & FIGURES, thus assuring the most accurate and timely data.

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The Society of the Plastics Industry, Inc.

General Statistics

DEVELOPMENT OF TODAY'S PLASTICS

Today's plastics are one of the most used materials on a volume basis in America's industrial and commercial life. The role of plastics is so broadly integrated in our own lifestyle that today there is virtually no product area where plastics do not make a major, irreplaceable contribution. Although the plastics industry in the United States is now in its second century, the most important developments have occurred since 1910. However, the roots of these modern develpoments go back not only to the research of cellulose nitrate by John Wesley Hyatt in the 1860's, but also to the plastic-like compositions used by man through the centuries.

ORIGIN OF PLASTICS

One can go as far back as the Old Testament to find references about natural materials used as fillers, adhesives, coatings, and the like. These materials were the precursors of what we call plastic materials today. Consequently, historians differ as to the exact date that the plastics industry began, and they will continue to do so since an exact year or even decade for the event is a matter of interpretation as to what constitutes a "plastic."

Certainly the history of the rubber industry has a bearing on plastics since ebonite, or hard rubber, discovered in 1851, was the first thermosetting material to be prepared and also the first material which involved a distinct chemical modification of a natural material. But ebonite was not exploited commercially for some years after its discovery and for that reason its historical importance has become somewhat blurred.

EUROPEAN DEVELOPMENTS

While the basic processes of rubber technology were developing, other important discoveries were taking place in Europe. Following work by Pelouze, Schonbein was able to establish conditions of controlled nitration of cellulose. The product soon became of interest as an explosive and in the manufacture of collodion, a cellulose solution in an alcohol-ether mixture. In the 1850's the English inventor Alexander Parkes observed that the solid residue left after the evaporation of the solvent of photographic collodion was a "hard, horny elastic and waterproof substance." In 1856 he patented the process of waterproofing woven fabrics by the use of such materials.

In 1862 the Great Exhibition was held in London. It was there that Parkes introduced a new material named for himself--Parkesine. Parkesine was obtained by dissolving cellulose nitrate in a minimum of solvent. The mixture was then put on a heated rolling machine from which some of the solvent was then removed. While still in the plastic state the material was then shaped by dies or pressure. In 1866 Parkes organized the Parkesine Company to manufacture products from his new material, but the company failed in 1868. This appears in part due to Parkes' attempt to reduce production costs which resulted in the production of inferior items.

One year after the failure of the Parkesine Company, an associate of Parkes, Daniel Spill, formed the Xylonite Company to manufacture products similar to Parkesine. Once again, economic failure resulted and Spill's company went bankrupt in 1874. Undaunted, Spill moved to a new site, established the Daniel Spill Company and continued production of his material, Xylonite.

FIRST PLASTICS IN THE U.S.

In the United States during the 1860's, someone else was experimenting with cellulose nitrate--John Wesley Hyatt. In 1865, Hyatt became involved in devising a method for producing billiard balls from materials other than Ivory. Originally using mixtures of cloth, ivory dust and shellac, in 1869 he patented the use of collodion for coating billiard balls. The patent came one year after his collodion material was introduced commerically.

John W. Hyatt and his brother Isaiah took out U.S. Patent 105,338 in 1870 for a process of producing a horn-like material using cellulose nitrate and camphor. Although Parkes and Spill had mentioned camphor in their work, it was the Hyatt brothers who recognized the value of camphor as a plasticizer for cellulose nitrate. In 1872, the term celluloid was coined by Isaiah Hyatt to describe the Hyatts' commerically successful product.

The validity of Hyatts' patents was challenged by Spill and a number of court actions took place between 1877 and 1884. In the final action, it was found that Spill had no claim on the Hyatt brothers, the judge ruling that the true inventor of the process was Parkes since he (Parkes) had mentioned the use of camphor in his patents. Thus, there was no restriction on the use of these processes and any company, including the Hyatts' Celluloid Manufacturing Company, was free to use them. After that decision, the Celluloid Manufacturing Company prospered, changed its name to the American Cellulose Chemical Corporation, and eventually was absorbed by the Celanese Corporation.

FORMALDEHYDE RESINS

Next to cellulose nitrate, the most important material in the early history of plastics was formaldehyde. Around 1897 there was a demand in German schools for a white chalkboard. Efforts to obtain such a product resulted in the discovery of casein plastics, produced by reacting casein (milk protein) with formaldehyde. The material soon became established under the trade names of Galalith and Erinoid, and today casein is still used by the button industry.

In 1899, Arthur Smith took out British Patent 16,275, the first dealing with phenol-formaldehyde resins, in this case for use as an ebonite substitute in electrical insulation. During the next decade, the phenol-formaldehyde reaction was investigated mainly for academic interest. In 1907, however, Leo Hendrik Baekeland discovered techniques of so controlling and modifying the reaction that useful products could be made from it. Thus phenolics were the first fully synthetic resins to become commerically successful.

Prompted by the success of phenolic moldings, research began on reacting other materials, such as urea and thiourea, with formaldehyde. These materials were used in the manufacture of molding powders. Unlike phenolics, they could be molded into light-colored articles and they rapidly achieved commerical success. Today these urea-based resins are used for molding powders, adhesives, and textile and paper finishing while the related melamine-formaldehyde resins are used in decorative laminates.

GROWTH OF MODERN PLASTICS

Cellulose acetate, a thermoplastic, was developed about the same time as the urea-based resins. Similar in structure to cellulose nitrate, it was found to be safer in processing and use. Cellulose acetate was introduced as a molding compound in 1927.

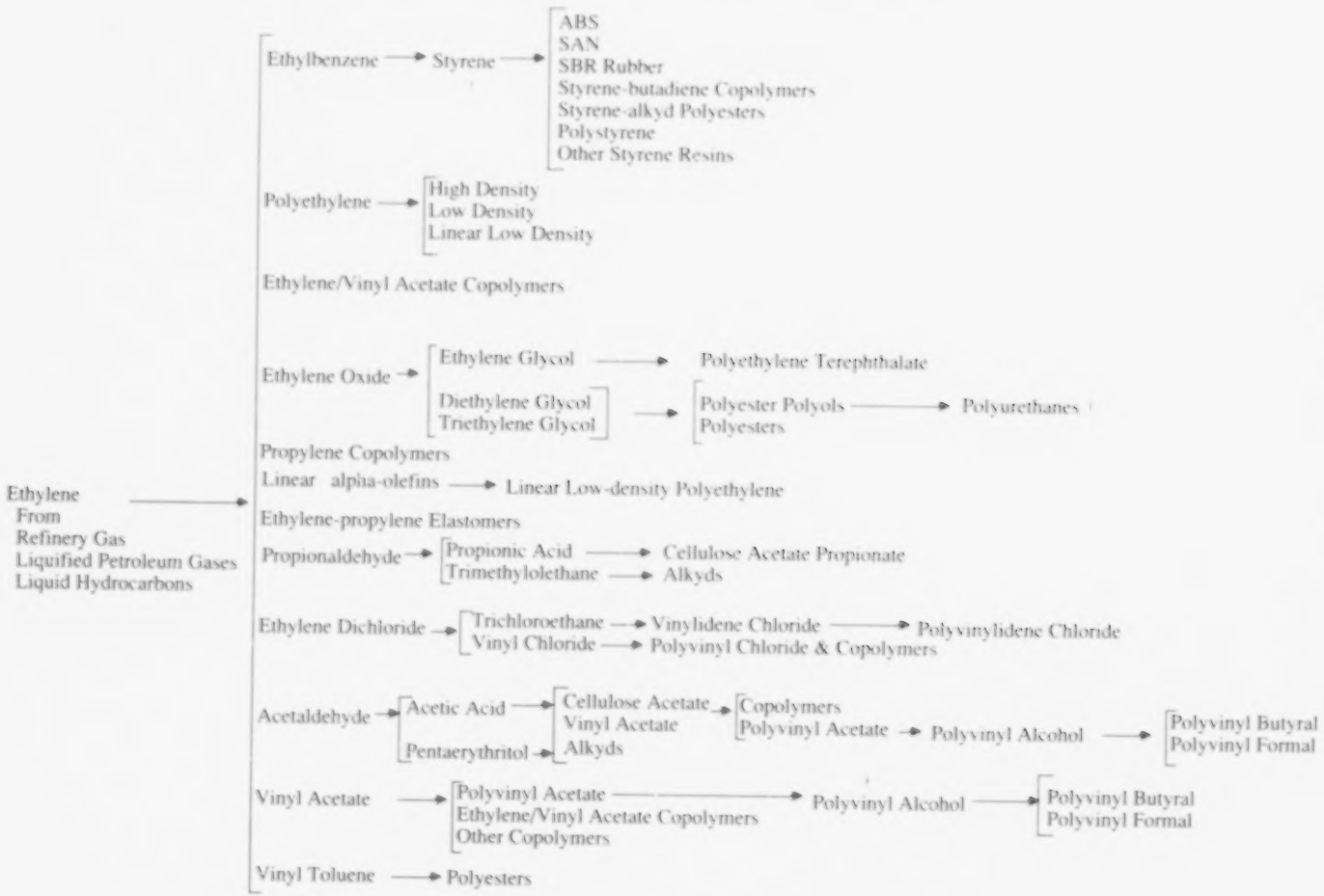
The period 1930-1940 saw the initial commercial development of today's major thermoplastics: polyvinyl chloride, low density polyethylene, polystyrene, and polymethyl methacrylate. The advent of the Second World War in 1939 brought plastics into great demand, largely as substitutes for materials in short supply, such as natural rubber. In the United States, the crash program leading to large-scale production of synthetic rubbers resulted in extensive research into the chemistry of polymer formation, and eventually, to the development of more plastic materials.

The first decade after World War II saw the development of high density polyethylene and polypropylene and the growth of the new plastics in many applications. Large-scale production of these materials reduced their cost dramatically. The new materials began to compete with the older plastics and even with the more traditional materials such as wood, paper, metal, glass and leather. Since that time, the demand for plastics has increased steadily so that plastics are now accepted by designers and engineers as basic materials along with the more traditional materials. The automotive industry, for instance, relies on plastics to reduce weight and thus increase mileage.

INTRODUCTION OF PLASTIC RESINS

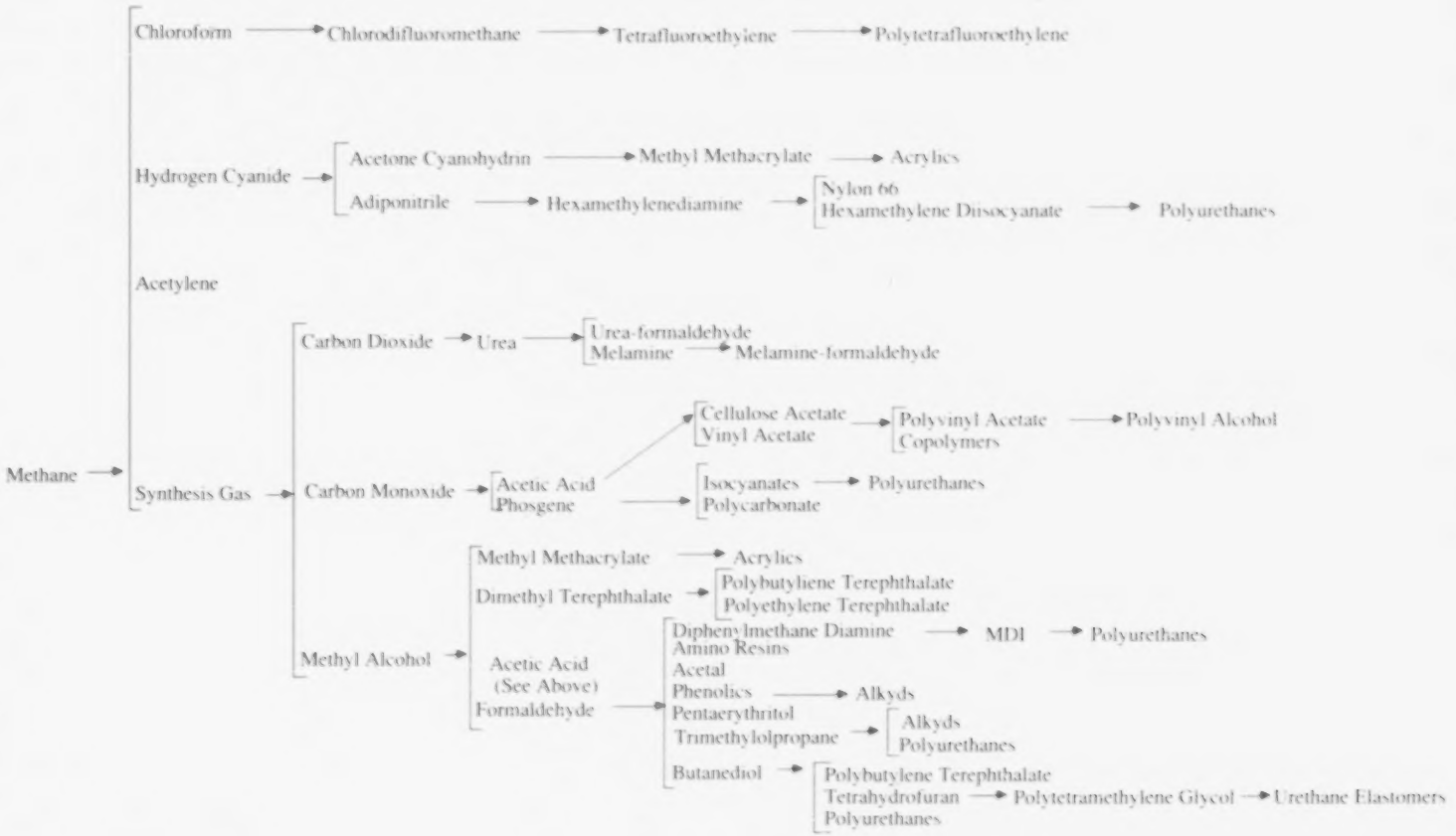
DATE	MATERIAL	EXAMPLE
1868	Cellulose Nitrate	Eye Glass Frames
1909	Phenol-Formaldehyde	Telephone Handset
1919	Casein	Knitting Needles
1926	Alkyd	Electrical Bases
1927	Cellulose Acetate	Tooth Brushes
1927	Polyvinyl Chloride	Wall Covering
1929	Urea-Formaldehyde	Lighting Fixtures
1935	Ethyl Cellulose	Flashlight Cases
1936	Acrylic	Brush Backs
1936	Polyvinyl Acetate	Flash Bulb Lining
1938	Cellulose Acetate Butyrate	Packaging
1938	Polystyrene	Housewares
1939	Nylon	Gears
1939	Polyvinylidene Chloride	Packaging Film
1939	Melamine-Formaldehyde	Tableware
1942	Unsaturated Polyester	Boat Hulls
1942	Low Density Polyethylene	Packaging
1943	Fluoropolymers	Industrial Gaskets
1943	Silicone	Motor Insulation
1945	Cellulose Propionate	Pens and Pencils
1947	Epoxy	Tools and Jigs
1948	Acrylonitrile-Butadiene-Styrene (ABS)	Luggage
1954	Styrene-Acrylonitrile (SAN)	Housewares
1954	Polyurethane	Foam Cushions
1956	Acetal	Automotive Parts
1957	High Density Polyethylene	Milk Bottles
1957	Polypropylene	Safety Helmets
1957	Polycarbonate	Appliance Parts
1959	Chlorinated Polyether	Valves and Fittings
1962	Phenoxy	Bottles
1964	Ionomer	Skin Packaging
1964	Polyphenylene Oxide	Battery Cases
1964	Polyimide	Bearings
1964	Ethylene-Vinyl Acetate	Adhesives and Coatings
1965	Polysulfone	Electrical/Electronic Parts
1970	Thermoplastic Polyester	Electrical/Electronic Parts
1973	Polybutylene	Piping
1973	Polyphenylene Sulfide	Telecommunications
1974	Polyethersulfone	Printed Circuit Boards
1975	Nitrile Barrier Resins	Non-food Packaging
1978	Linear Low Density Polyethylene	Extruded Film
1982	Polyetherimide	Electrical/Electronic Parts
1983	Polyetheretherketone	Wire and Cable
1984	Aromatic Copolyester	Electrical/Electronic Parts
1985	Liquid Crystal Polymers	Electrical/Electronic Parts
1988	Polymethylpentene	High temp./transparent

Plastics Derived From Ethylene



Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Methane

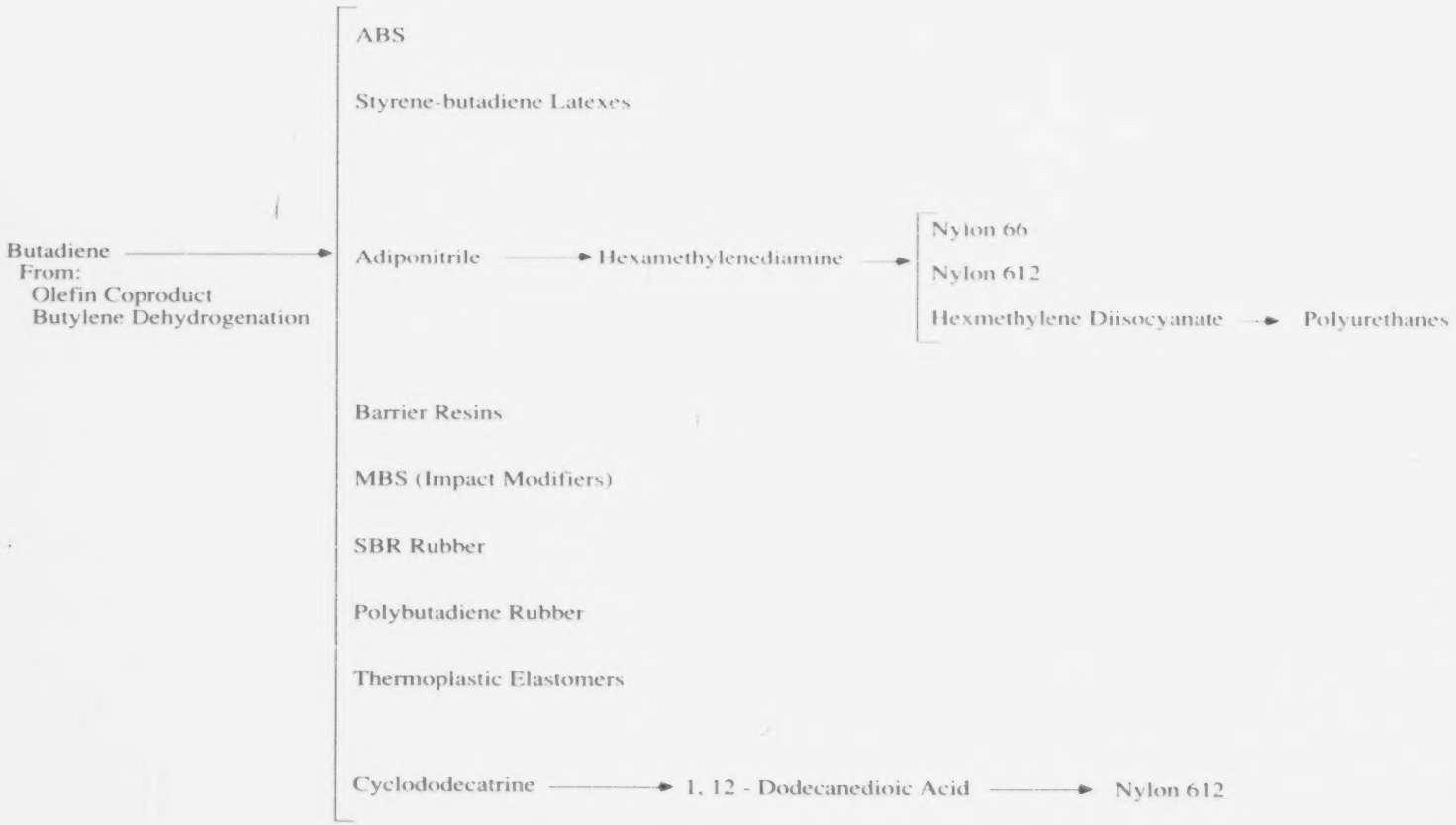


Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Acetylene

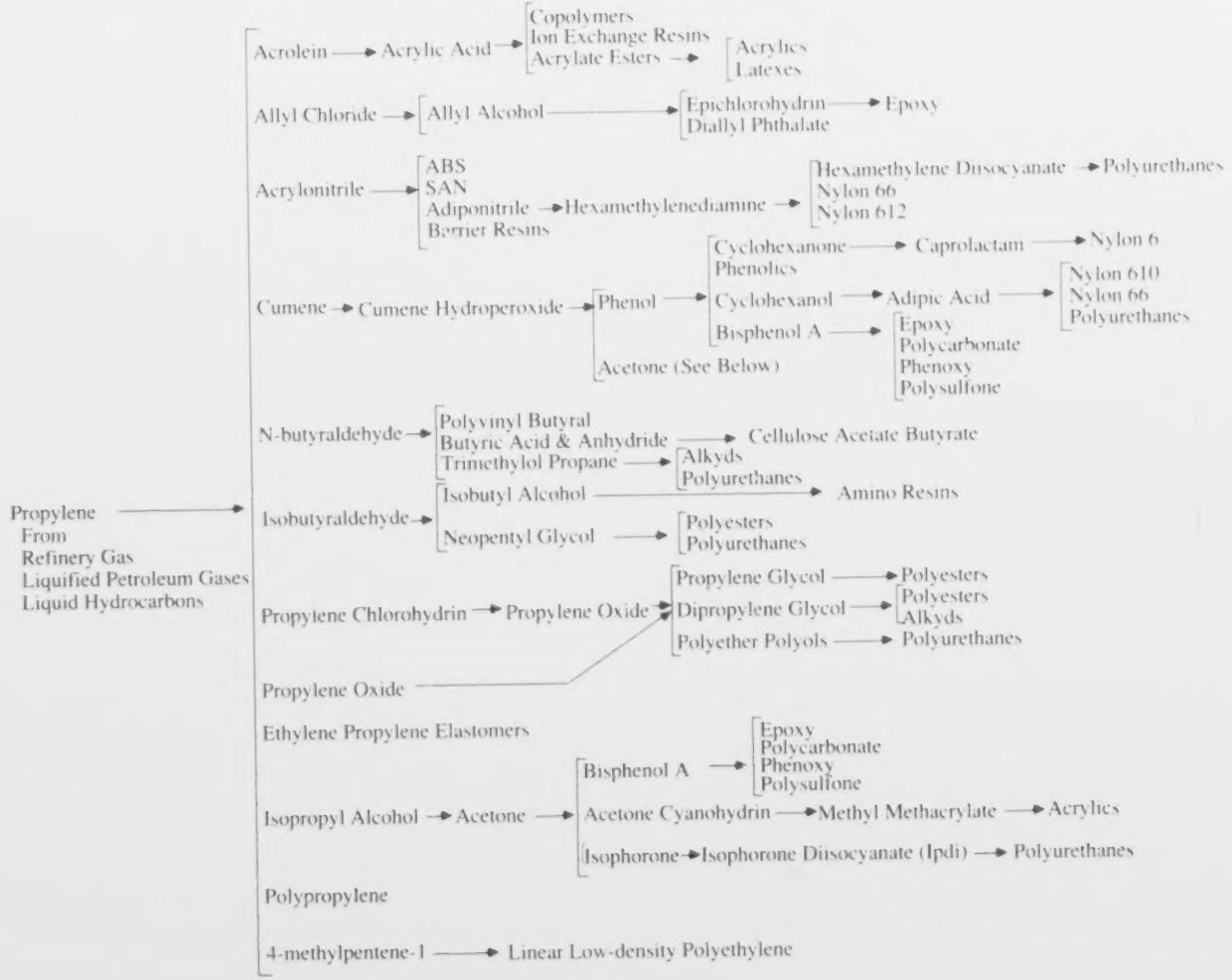
Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Butadiene



Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Propylene

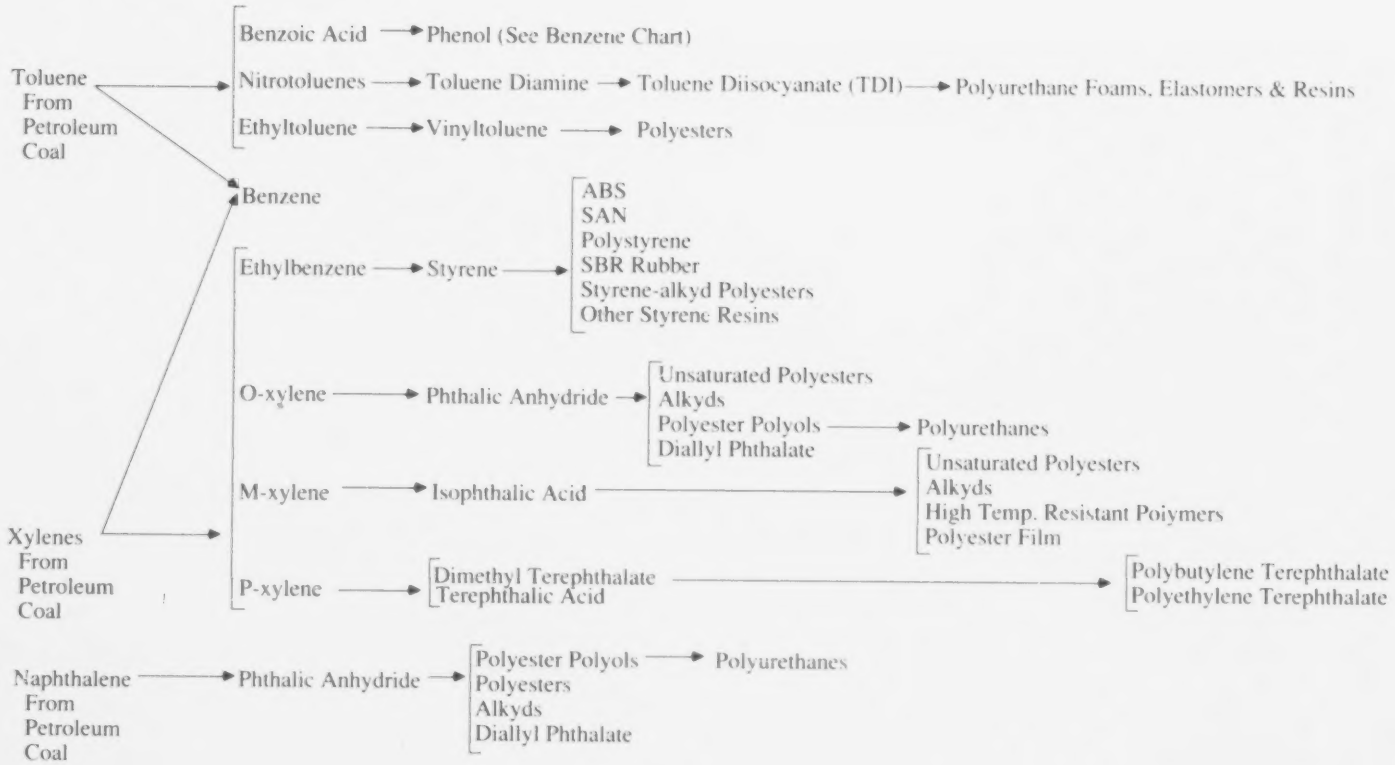


Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Benzene

Source: Extracted in part from SRI International, Chemical Origins & Markets

Plastics Derived From Naphthalene, Toluene & Xylenes



Source: Extracted in part from SRI International, Chemical Origins & Markets

PLASTIC MATERIALS & RESINS

VALUE OF SHIPMENTS

(in millions of dollars)

VERSUS LARGEST CHEMICAL CATEGORIES	1987[1]	1988[2]	1989[3]	COMPOUND GROWTH RATE 1987-1989
Industrial Organic Chemicals	50,972	56,745	63,754	12.0%
Drugs	39,090	43,091	46,774	9.5
Soaps, Cleaners & Toilet Goods	34,427	37,180	39,675	7.3
Plastic Materials & Resins	**26,144**	**33,800**	**36,616**	**18.3**
Industrial Inorganic Chemicals	17,157	20,332	20,770	10.0
Paints and Allied Products	12,600	13,872	14,982	9.0
Agricultural Chemicals	12,579	14,702	15,951	12.5

VERSUS OTHER COMMODITIES	1987[1]	1988[2]	1989[3]	COMPOUND GROWTH RATE 1987-1989
Steel Mill Products	51,488	62,815	62,435	10.0%
Paper and Board	42,843	49,450	53,000	11.5
Plastic Materials & Resins	**26,144**	**33,800**	**36,616**	**18.3**
Yarn Spinning Mills	7,094	7,335	7,643	4.0
Cement	4,319	4,302	4,255	-1.0
Synthetic Rubber	3,310	3,339	3,390	1.0
Leather Tanning & Finishing	2,215	2,328	2,461	5.3

1. Industry data is preliminary.
2. Estimated, except for exports and imports.
3. Estimated

Source: U.S. Department of Commerce

SIC CODES

The Plastics Industry and SIC Codes

The Standard Industrial Classification (SIC) is a numerical system developed by the Federal government to classify the total economy into different industry segments. It is a classification of establishments[1] by type of economic activity in which they are engaged. Its purposes are (1) to facilitate the collection, tabulation, presentation and analysis of data relating to establishments and (2) to promote uniformity and comparability in the presentation of statistical data collected by various agencies of the federal government, state agencies, trade associations and private research organizations.

Among the uses for the SIC system, the two- and four-digit SIC codes are the basis for agencies such as EPA and OSHA to target certain industry segments for regulatory activity.

The History of SIC's

The SIC system was inaugurated in 1945 and at first, covered only manufacturing industries. Four years later, the program was revised and enlarged to include all sectors of economic activity.

Periodically since then, the program has been refined further to reflect changes in the composition and structure of the U.S. economy. The incorporation of these changes and updates takes place about every five years. Changes may include refinements in industry detail or coverage, improvements in industry definitions or clarification of industry classifications.

Major revisions, such as the addition of new industry codes, occur only once every ten years. The 1987 edition of the Standard Industrial Classification Manual that was released in May 1989 reflects such a major revision that affects the plastics industry.

What's New

According to the Office of Management and Budget, the 1987 SIC revision has taken into account technological changes; institutional changes such as deregulation in the banking, communications and transportation industries, and the tremendous expansion in the service sector.

For the plastics, this revision includes the division of "miscellaneous plastics products" into nine separate SIC industry codes as opposed to the single listing for that category (3079) that had been in existence since 1947. The breakdown reflects the tremendous growth of the plastics industry and was intended to allow the industry to keep track of more detailed statistics.

How It Works

In most of these publications, each project or service is identified by a seven-digit code. This classification system operates so that the industrial coverage is progressively narrower with th successive addition of digits.

Classification of Major Industries

SIC Code Range	Economic Division
01, 02, 07-09	Agriculture, Forestry, Fishing
10-14	Mining
15-17	Construction
20-39	Manufacturing
40-49	Transportation, Public Utilities
50-51	Wholesale Trade
52-59	Retail Trade
60-67	Finance, Insurance, Real Estate
70-89	Services
91-97	Public Administration

1987 Census of Manufactures and the Plastics Industry

New industry data includes the addition of the nine new codes that have now replaced the single four-digit listing (3079) for " miscellaneous plastics products."

Industry Code	Description
3081	Unsupported plastics film & sheet
3082	Unsupported plastics profile shapes
3083	Laminated plastics plate, sheet & profile shapes
3084	Plastics pipe
3085	Plastics bottles
3086	Plastics foam products
3087	Custom compounding of purchased resins
3088	Plastics plumbing fixtures
3089	Plastics products, not elsewhere classified

[1] An establishment is a single location at which economic activity (i.e. manufacturing) takes place. It is synonymous with "plant".

General Statistics

PLASTIC MATERIALS & RESINS

(SIC 2821)

(millions of dollars except as noted)

	1987[1]	1988[2]	1989[3]	PERCENT CHANGE 1987-88	PERCENT CHANGE 1988-89
Industry Data					
Value of shipments[5]	26,144	33,800	36,616	29.3	8.3
Value of shipments (1987$)	26,144	27,614	28,166	5.6	2.0
Total employment (000)	55.9	55.5	55.5	-0.7	0.0
Production workers (000)	34.7	-	-	-	-
Average hourly earnings ($)	15.24	-	-	-	-
Product Data					
Value of shipments[6]	27,698	-	-	-	-
Value of shipments (1987$)	27,698	-	-	-	-
Trade Data					
Value of imports	927	1,158	1,273	24.9	9.9
Import/new supply ratio[7]	0.032	-	-	-	-
Value of exports	3,688	5,304	5,437	36.5	8.0
Export/shipment ratio	0.133	-	-	-	-

MISCELLANEOUS PLASTIC PRODUCTS

(SIC 308)

(millions of dollars except as noted)

	1987[1]	1988[2]	1989[3]	PERCENT CHANGE 1987-88	PERCENT CHANGE 1988-89
Industry Data					
Value of shipments[5]	60,394	64,831	68,186	7.3	5.2
Value of shipments (1987$)	60,394	62,787	65,281	4.0	4.0
Total employment (000)	590	-	-	-	-
Production workers (000)	459	-	-	-	-
Average hourly earnings ($)	8.39	-	-	-	-
Product Data					
Value of shipments[5]	60,607	65,555	68,718	8.2	4.8
Value of shipments (1987$)	60,607	63,248	65,765	4.4	4.0
Trade Data					
Value of imports	3,540	4,607	5,759	30.1	25.0
Value of exports	2,668	3,414	4,122	28.0	20.7

[1]Industry & product data are preliminary.
[2]Estimated, except for exports and imports.
[3]Estimated.
[4]Forecast, not included in this reporduction.
[5]Value of products sold.
[6]Value of products in the industry produced by all industries.
[7]New supply is imports plus corresponding product shipments.

SOURCE: U.S. Department of Commerce: Bureau of the Census, Bureau of Economic Analysis, International Trade Administration (ITA). Estimates and forecasts by ITA.

PROFILE OF 25 LARGEST MANUFACTURING INDUSTRIES

RELATIVE 1989 RANK	SIC	INDUSTRY	1989 INDUSTRY SHIPMENTS (MIL. 1982$)
1	2911	Petroleum refining	$ 219,857
2	3711	Motor vehicles & car bodies	108,147
3	3674	Semiconductors & related devices	58,549
4	3719	Motor vehicle parts & accessories	56,444
► **5**	**308**	**Miscellaneous Plastics Products**	**55,549**
6	3662	Radio & TV communication equipment	51,465
7	331A	Steel mill products	46,946
8	2011	Meatpacking plants	42,785
9	275A	Commercial printing	39,121
10	3721	Aircraft	35,450
11	2869	Industrial organic chemicals	34,550
12	2621	Papermills, except building paper	26,780
► **13**	**2821**	**Plastic Materials & Resins**	**26,079**
14	2834	Pharmaceutical preparations	24,140
15	3761	Guided missles & space vehicles	23,900
16	2711	Newspapers	23,240
17	2086	Bottled & canned soft drinks	21,600
18	3861	Photographic equipment & supplies	20,211
19	3728	Aircraft equipment	19,920
20	3724	Aircraft engines & enginr parts	19,400
21	2026	Fluid milk	19,185
22	2022	Natural & processed cheese	14,947
23	3661	Telephone & telegraph apparatus	14,796
24	2013	Sausages & other prepared meats	14,750
25	3465	Automotive stampings	14,500

Source: U.S. Department of Commerce

PLASTICS PROCESSING INDUSTRY

BY SALES GROUPS--1989

BALANCE SHEET[1] (Number of Responses)	TOTAL [134]	SALES VOLUME < $5MM [47]	$5-10MM [18]	$10-25MM [37]	> $25MM [32]
Cash and Marketable Securities	6.6	8.8	6.6	6.0	4.0
Accounts Receivable	25.8	27.2	29.4	25.0	22.3
Raw Materials	10.1	11.0	10.3	11.0	7.8
Work in Progress	2.2	2.2	3.0	2.4	1.6
Finished Goods	8.1	7.2	7.7	7.5	10.2
LIFO Reserve	(1.3)	(0.3)	(1.8)	(1.8)	(2.0)
Inventory, Total	18.8	19.6	19.3	18.7	17.4
Other Current Assets Total	4.0	4.8	5.3	3.2	3.3
TOTAL CURRENT ASSETS	55.2	60.4	60.6	52.9	47.0
Land and Buildings (net of depreciation)	10.1	4.2	9.1	13.6	15.1
Machinery and Equipment (net of depreciation)	28.5	30.7	26.4	25.2	30.5
Other Long Term Assets	6.2	4.7	3.9	8.3	7.4
TOTAL ASSETS	100.0	100.0	100.0	100.0	100.0
Accounts Payable	14.5	15.3	18.8	14.9	10.1
Other Current Liabilities	9.4	9.0	11.6	10.2	8.0
Notes Payable	13.3	15.1	9.1	15.5	10.8
Current Portion of Long Term Debt	5.0	6.0	6.5	4.2	3.4
TOTAL CURRENT LIABILITIES	42.2	45.4	46.0	44.8	32.3
Long Term Debt (less current portion)	7.4	6.3	7.6	4.9	11.8
TOTAL LIABILITIES	49.6	51.7	53.6	49.7	44.1
EQUITY (NET WORTH)	50.4	48.3	46.4	50.3	55.9
TOTAL LIABILITIES and NET WORTH	100.0	100.0	100.0	100.0	100.0
INCOME STATEMENT[2]					
NET SALES	100.0	100.0	100.0	100.0	100.0
Direct Materials	42.0	36.2	42.7	44.0	47.8
Direct Labor	10.3	12.9	9.9	9.8	7.3
Indirect Labor	6.4	5.7	7.4	6.7	7.0
Manufacturing Personnel Fringe Benefits	4.0	3.3	4.0	4.4	4.5
Depreciation Expense	3.4	3.7	2.8	2.9	3.9
Other Manufacturing Expense	11.5	12.2	11.8	11.6	10.4
LIFO Valuations	0.1	0.2	>0.1	0.2	(0.1)
Total Production Related Expenses (COGS)	77.7	73.9	78.6	79.6	80.8
GROSS MARGIN	22.3	26.1	21.4	20.4	19.2
Sales Salaries, Commissions, Fringe Benefits	3.1	3.4	3.7	3.0	2.4
Other Selling Expense	1.8	1.8	2.0	1.3	2.1
Administrative Expense (includes Engineering & R&D Salaries)	10.0	14.4	7.8	8.0	7.0
Other Engineering/R&D Expense	0.4	0.4	0.5	0.3	0.4
Total Non-Production Related Expenses	15.3	20.0	14.0	12.6	11.9

Some companies did not respond to every line item, therefore the sum of the average breakouts may not equal the average total.
[1] Averages as a percent of Total Assets. [2] Averages as a percent of Net Sales.
Source: SPI Financial & Operating Ratios Survey

PLASTICS PROCESSING INDUSTRY

BY SALES GROUPS--1989

(CONCLUDED)

INCOME STATEMENT [2] (CONCLUDED)	TOTAL [157]	SALES VOLUME < $5MM [52]	$5-10MM [27]	$10-25MM [46]	> $25MM [31]
OPERATING MARGIN	7.0	6.1	7.4	7.8	7.3
Interest Expense (Income)	1.4	1.5	1.2	1.2	1.7
Other Expense (Income)	0.3	0.9	>.01	(0.1)	0.1
Profit Before Income Taxes	5.3	3.7	6.2	6.7	5.5
Income Taxes	1.2	0.6	2.2	1.3	1.1
Profit After Income Taxes	4.3	3.2	4.0	5.4	5.1
STATISTICAL DATA [3]					
Net Sales/Average Number Employees	$ 95,677	$ 72,239	$ 95,858	$ 104,343	$ 121,903
Net Sales/All Employee Hours	$ 48	$ 36	$ 49	$ 53	$ 59
Net Sales/Production Worker Hours	$ 74	$ 55	$	$ 76	$ 91
Total Employment Costs/Net Sales	29.8%	33.1%	29.5%	29.0%	25.8%
Production Worker Employment Costs/Net Sales	20.7%	21.5%	21.3%	20.9%	18.8%
Total Employment Costs/LBS. Processed	$ 1.09	$ 1.69	$ 0.98	$ 0.87	$ 0.59
Production Worker Employment Costs/LBS. Processed	$ 0.75	$ 1.10	$ 0.73	$ 0.63	$ 0.43
COGS/LBS. Processed	$ 2.52	$ 3.28	$ 2.56	$ 2.23	$ 1.80
Productive Machine Hrs./Available Machine Hrs.	53.5%	45.6%	56.5%	55.5%	60.3%
Inventory Turnover (times)	10.7	12.1	10.1	10.9	9.0
Average Collection Period (days)	49	50	56	45	50
Return on Assets (before tax)	11.8%	11.6%	12.0%	13.3%	10.1%
Return on Equity (before tax)	25.8%	27.9%	31.8%	24.6%	21.1%
Return on Assets (after tax)	9.8%	10.3%	7.7%	10.7%	9.1%
Return on Equity (after tax)	19.9%	21.1%	21.2%	20.1%	17.5%
Percent Change in Net Sales (1988-1989)	9.8%	8.8%	16.3%	9.0%	8.4%

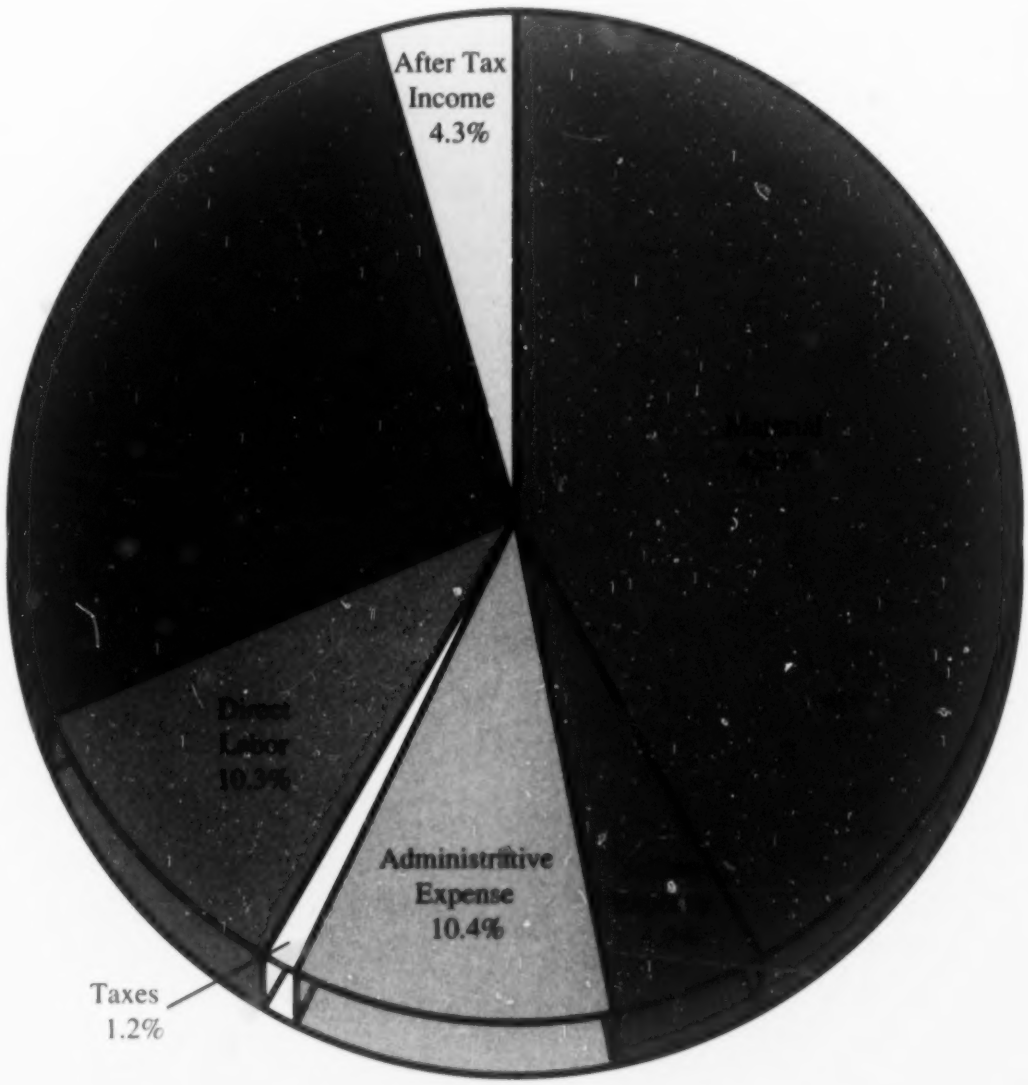
[2] Averages as a percent of Net Sales.

[3] Each average is calculated using only those companies providing data necessary for the respective calculation.

Source: SPI Financial & Operating Ratios Survey.

PLASTICS PROCESSING COMPANIES *

SALES DOLLAR BREAKDOWN



* Includes custom processors and proprietary processors.

The Society of the Plastics Industry, Inc.

Major Markets

CATEGORIES

The primary product groups for each Major Market category are listed below:

A. TRANSPORTATION

Motor Vehicles and Parts: including autos, trucks, buses, motorcycles, and bicycles
All Other: including railroad equipment, travel trailers, campers, golf carts, snowmobiles, aircraft, military vehicles, ships, boats and recreational vehicles.

B. PACKAGING

Bottles, Jars, Vials
Food Containers: excluding disposable cups
Flexible Packaging: including household and institutional refuse bags and film
All Other: including tubes, tape, strapping, drums, caps, baskets, trays, boxes, pallets, shipping crates, pails, buckets, shipping cases, blister and bubble containers.

C. BUILDING AND CONSTRUCTION

Pipe, Conduit and Fittings: including drainage, irrigation, plumbing fixtures, and septic tanks
Building Material for all Structures: including siding, flooring, and insulation materials
All Other: including panels, doors, windows, skylights, bathroom units, gratings and railings.

D. ELECTRICAL/ELECTRONIC

Home and Industrial Appliances: including electrical industrial equipment, wire and cable coverings, communications equipment
Electronic Components: including resistors, magnetic tape, records, and batteries.

E. FURNITURE AND FURNISHINGS

Rigid and Flexible Types: including household and office furniture, bedding, carpets, rugs, backing, curtains, blinds, awnings, lamps, picture frames, and wall coverings.

F. CONSUMER AND INSTITUTIONAL PRODUCTS

Disposable Food Serviceware: including disposable cups
Dinner and Kitchenware: including picnicware
Toys and Sportings Goods
Health Care and Medical Products: including laboratory supplies
Hobby and Graphic Arts Supplies: including photographic equipment and supplies
All Other: including footwear, luggage, buttons, lawn & garden tools, signs & displays, and credit cards.

G. INDUSTRIAL/MACHINERY

All Types: including engine and turbine parts, farm and garden machinery, construction and related equipment, machine tools, ordnance and firearms, and chemical process equipment.

H. ADHESIVES/INKS/COATINGS

Adhesives and Sealants
All Other: including printing ink, magnet wire enamels, core binders, foundry facings, paper coating and glazing, paints, varnishes, and enamels.

I. ALL OTHER

Sales of Resins Sold to Resellers and Compounders
Other sales of resins which cannot be classified under any Major Market category A through H.

J. EXPORTS

Sales of Plastic Resin exported from the U.S.

Major Markets

1989

1989 major market volumes are derived from plastic resin Sales & Captive Use data as compiled by Ernst & Young. This study reflects data collected for the following individual resin categories:

THERMOSETS

Epoxy
Polyester, Unsaturated
Urea and Melamine
Phenolic

THERMOPLASTICS

Low Density Polyethylene
High Density Polyethylene
Polypropylene
Acrylonitrile-Butadiene-Styrene (ABS) and Styrene-Acrylonitrile (SAN)
Polystyrene
Styrene Butadiene Latexes (SBL), and Other Styrene Based Latexes (OSBL), and Other Styrene Based Polymers (OSBP)
Nylon
Polyvinyl Chloride
Other Vinyls
Thermoplastic Polyester
Engineering Resins

TOTAL RESIN SALES & CAPTIVE USE

BY MAJOR MARKET

(millions of pounds, dry weight basis)

MAJOR MARKET	1985	1986	1987	1988	1989
Transportation	1,989	1,988	2,029	2,278	2,547
Packaging	12,774	13,267	15,234	16,068	14,711
Building and Construction	10,038	10,085	11,285	11,449	11,096
Electrical/Electronic	2,659	2,609	2,779	3,024	3,145
Furniture and Furnishings	2,107	2,191	2,235	2,138	2,285
Consumer and Institutional	3,975	4,123	5,063	5,210	6,217
Industrial/Machinery	364	361	332	744	475
Adhesives/Inks/Coatings	2,142	1,638	1,797	1,245	1,211
All Other	5,122	4,555	4,665	9,337	10,911
Exports	4,170	4,206	4,593	*	*
Total	**45,340**	**45,023**	**50,012**	**51,493**	**52,598**

*Amount is included in All Other.

COMPARATIVE PERCENTAGE DISTRIBUTION

BY MAJOR MARKET

MAJOR MARKET	1985	1986	1987	1988	1989
Transportation	4.4%	4.4%	4.1%	4.4%	4.8%
Packaging	28.2	29.5	30.4	31.2	28.0
Building and Construction	22.1	22.4	22.6	22.2	21.1
Electrical/Electronic	5.9	5.8	5.6	5.9	6.0
Furniture and Furnishings	4.7	4.9	4.5	4.2	4.3
Consumer and Institutional	8.8	9.2	10.0	10.1	11.8
Industrial/Machinery	0.8	0.8	0.7	1.5	0.9
Adhesives/Inks/Coatings	4.7	3.6	3.6	2.4	2.3
All Other	11.2	10.1	9.3	18.1	20.8
Exports	9.2	9.3	9.2	-	-
Total	100.0%	100.0%	100.0%	100.0%	100.0%

PERCENTAGE CHANGE IN SALES AND USE

BY MAJOR MARKET

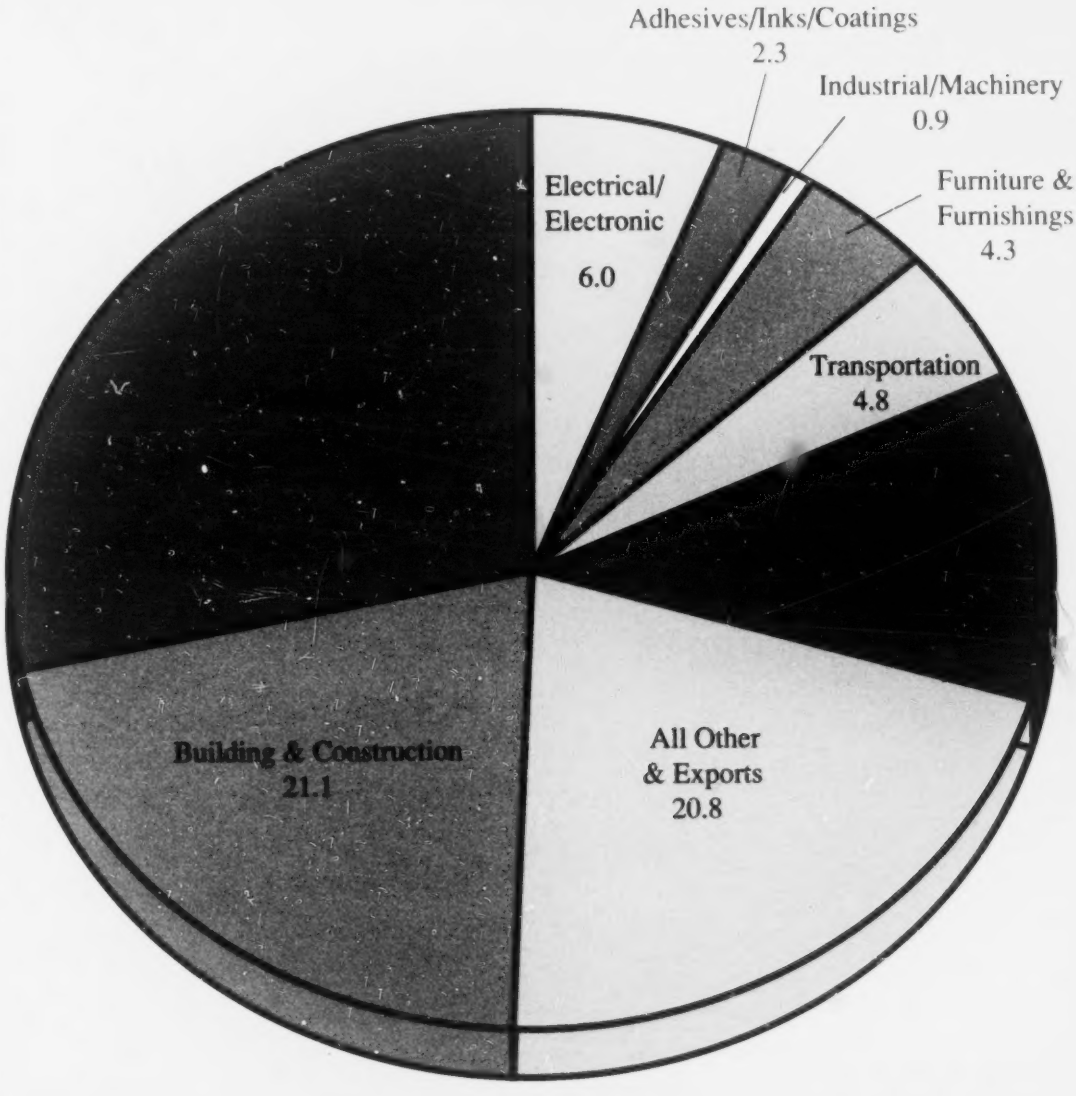
MAJOR MARKET	% CHANGE 1987/1988	% CHANGE 1988/1989
Transportation	12.3%	11.8%
Packaging	5.5	-8.5
Building and Construction	1.5	-3.1
Electrical/Electronic	8.8	4.0
Furniture and Furnishings	-4.4	6.9
Consumer and Institutional	2.9	19.3
Industrial/Machinery	124.1	-36.2
Adhesives/Inks/Coatings*	-30.7	-2.7
All Other	20.0	16.9
Exports	NA	NA
Total*	3.0%	2.1%

* % change approximate, due to reporting changes in 1989.
NA = Not Available

1989 DISTRIBUTION OF PLASTIC RESIN SALES & CAPTIVE USE BY MAJOR MARKET

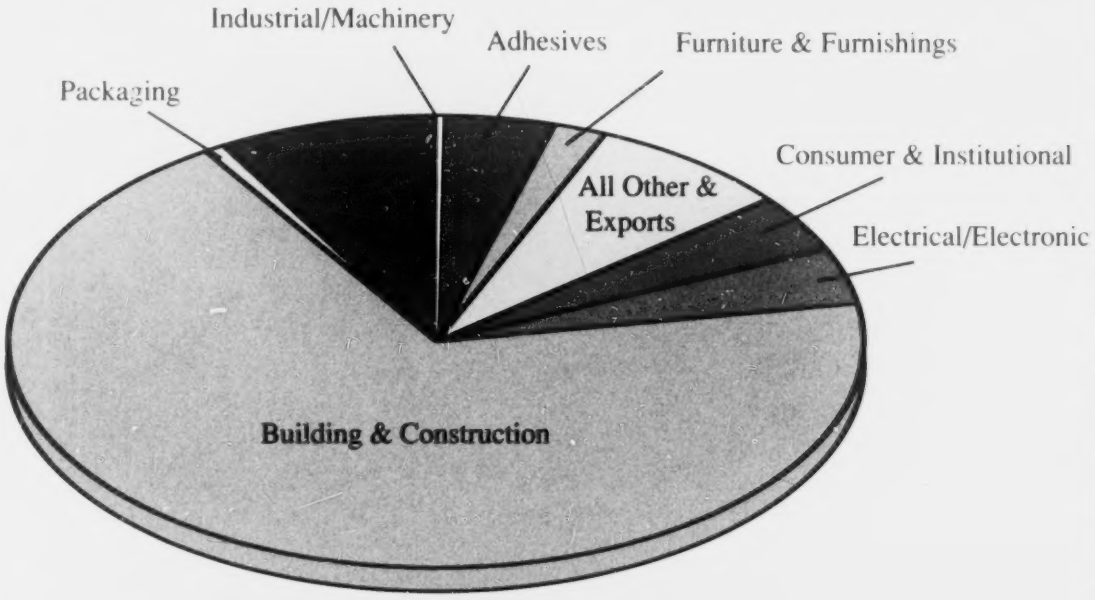
(PERCENT)

ALL RESINS

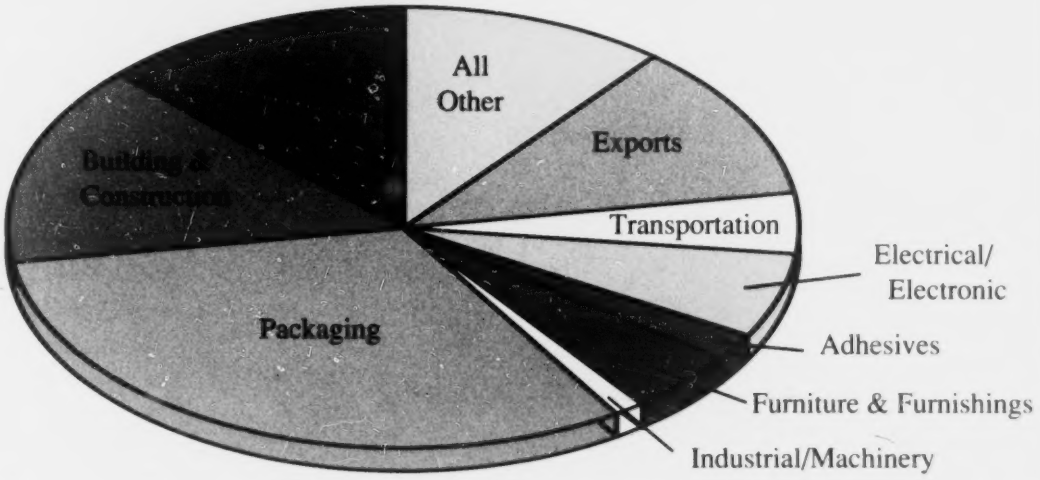


1989 DISTRIBUTION OF PLASTIC RESIN SALES & CAPTIVE USE BY MAJOR MARKET

THERMOSET RESINS



THERMOPLASTIC RESINS



1989 DISTRIBUTION OF PLASTIC RESINS SALES & CAPTIVE USE

Total Thermosets & Thermoplastics

(Thousands of Pounds, Dry Weight Basis)^1

MAJOR MARKET	TOTAL THERMOSETS		TOTAL THERMOPLASTICS		GRAND TOTAL	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	526,317	8.32%	2,021,060	4.37%	2,547,377	4.84%
PACKAGING, TOTAL	56,529	0.89%	14,654,578	31.67%	14,711,107	27.97%
BUILDING AND CONSTRUCTION, TOTAL	4,333,390	68.52%	6,762,352	14.61%	11,095,742	21.10%
ELECTRICAL/ELECTRONIC, TOTAL	249,982	3.95%	2,895,438	6.26%	3,145,420	5.98%
FURNITURE AND FURNISHINGS, TOTAL	118,437	1.87%	2,167,098	4.68%	2,285,535	4.35%
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	260,779	4.12%	5,955,781	12.87%	6,216,560	11.82%
INDUSTRIAL/MACHINERY, TOTAL	21,779	0.34%	453,050	0.98%	474,829	0.90%
ADHESIVES/INKS/COATINGS, TOTAL	260,113	4.11%	951,222	2.06%	1,211,335	2.30%
ALL OTHER, TOTAL ^2	497,366	7.88%	5,036,450	10.88%	10,910,541	20.74%
EXPORTS, TOTAL	D		5,376,725	11.62%	D	
GRAND TOTAL	6,324,692	100.00%	46,273,754	100.00%	52,598,446	100.00%

^1 - Phenolic is on a Gross Weight Basis

D = Disclosure, amount is included in All Other, Total.

^2 - Disclosure Data is included in All Other, Total for individual resins (pp. 28 - 30). However, for resin class totals above, such disclosure data can be distributed by Major Market category without any disclosure. Therefore, All Other, Total as shown above, is less than the sum of All Other, Total for Thermoset and Thermoplastic resins (pp. 28 - 30).

Compiled By Ernst & Young, Washington, D.C., for SPI's Committee on Resin Statistics (CRS)

1989 DISTRIBUTION OF PLASTIC RESINS SALES & CAPTIVE USE

Thermoset/Thermoplastic Resins

(Thousands of Pounds, Dry Weight Basis)^1

MAJOR MARKET	EPOXY		POLYESTER		UREA & MELAMINE		PHENOLICS		LOW DENSITY PE	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	D		462,541	35.52%	D		38,925	1.36%	105,035	0.97%
PACKAGING, TOTAL	5,706	1.19%	D		41,876	2.50%	D		5,688,472	52.66%
BUILDING AND CONSTRUCTION, TOTAL	42,695	8.86%	487,901	37.48%	1,296,763	77.27%	2,506,031	87.53%	417,447	3.86%
ELECTRICAL/ELECTRONIC, TOTAL	87,551	18.18%	39,158	3.01%	D		D		D	
FURNITURE AND FURNISHINGS, TOTAL	D		17,158	1.32%	28,846	1.72%	D		D	
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	D		122,878	9.44%	D		D		1,611,286	14.92%
INDUSTRIAL/MACHINERY, TOTAL	D		2,496	0.19%	0	0.00%	D		112,106	1.04%
ADHESIVES/INKS/COATINGS, TOTAL	D		18,700	1.44%	D		25,550	0.89%	306,395	2.84%
ALL OTHER, TOTAL	259,649	53.91%	126,842	9.74%	310,725	18.51%	272,720	9.53%	1,440,391	13.33%
EXPORTS, TOTAL	86,033	17.86%	24,236	1.86%	D		19,712	0.69%	1,121,700	10.38%
GRAND TOTAL	481,634	100.00%	1,301,910	100.00%	1,678,210	100.00%	2,862,938	100.00%	10,802,832	100.00%

^1 - Phenolic is on a Gross Weight Basis

D = Disclosure, amount is included in All Other, Total.

1989 DISTRIBUTION OF PLASTIC RESINS SALES & CAPTIVE USE

Thermoplastic Resins

(Thousands of Pounds, Dry Weight Basis)

MAJOR MARKET	HIGH DENSITY PE		POLYPROPYLENE		ABS & SAN		POLYSTYRENE		STYRENE LATEX & OSBP	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	208,927	2.56%	389,666	5.34%	337,635	25.48%	D		D	
PACKAGING, TOTAL	4,353,340	53.27%	1,446,617	19.81%	D		1,339,690	26.11%	D	
BUILDING AND CONSTRUCTION, TOTAL	683,200	8.36%	111,087	1.52%	D		502,423	9.79%	D	
ELECTRICAL/ELECTRONIC, TOTAL	154,628	1.89%	197,148	2.70%	D		782,765	15.26%	D	
FURNITURE AND FURNISHINGS, TOTAL	D		1,313,300	17.98%	D		205,029	4.00%	243,160	20.61%
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	862,496	10.55%	1,305,723	17.87%	D		1,189,393	23.18%	16,056	1.36%
INDUSTRIAL/MACHINERY, TOTAL	D		0	0.00%	D		D		D	
ADHESIVES/INKS/COATINGS, TOTAL	23,856	0.29%	0	0.00%	0	0.00%	0	0.00%	427,479	36.23%
ALL OTHER, TOTAL	963,630	11.79%	1,279,218	17.52%	987,468	74.52%	886,845	17.29%	493,143	41.80%
EXPORTS, TOTAL	922,746	11.29%	1,260,167	17.26%	N/A		224,402	4.37%	D	
GRAND TOTAL	8,172,833	100.00%	7,302,926	100.00%	1,325,103	100.00%	5,130,547	100.00%	1,179,838	100.00%

D = Disclosure, amount is included in All Other, Total.
N/A = Not Available. Amount is included in All Other, Total.

1989 DISTRIBUTION OF PLASTIC RESINS SALES & CAPTIVE USE

Thermoplastic Resins

(Thousands of Pounds, Dry Weight Basis)

MAJOR MARKET	NYLON		PVC		OTHER VINYL		THERMOPLASTIC POLYESTER		ENGINEERING	
	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total	Quantity	Percent Of Total
TRANSPORTATION, TOTAL	155,716	26.82%	159,526	1.88%	D		D		D	
PACKAGING, TOTAL	85,945	14.81%	582,101	6.85%	D		1,024,766	60.02%	D	
BUILDING AND CONSTRUCTION, TOTAL	21,844	3.76%	4,782,387	56.30%	D		D		49,848	3.62%
ELECTRICAL/ELECTRONIC, TOTAL	88,955	15.32%	573,185	6.75%	0	0.00%	D		D	
FURNITURE AND FURNISHINGS, TOTAL	24,501	4.22%	284,363	3.35%	D		D		D	
CONSUMER AND INSTITUTIONAL PRODUCTS, TOTAL	40,030	6.90%	656,504	7.73%	0	0.00%	D		80,539	5.85%
INDUSTRIAL/MACHINERY, TOTAL	36,938	6.36%	D		0	0.00%	4,818	0.28%	41,809	3.03%
ADHESIVES/INKS/COATINGS, TOTAL	6,533	1.13%	164,799	1.94%	14,319	7.12%	D		D	
ALL OTHER, TOTAL	42,696	7.36%	372,428	4.39%	116,164	57.78%	391,954	22.96%	915,228	66.44%
EXPORTS, TOTAL	77,328	13.32%	917,918	10.81%	70,569	35.10%	285,801	16.74%	290,163	21.06%
GRAND TOTAL	580,486	100.00%	8,493,211	100.00%	201,052	100.00%	1,707,339	100.00%	1,377,587	100.00%

D = Disclosure, amount is included in All Other, Total.

Compiled By Ernst & Young, Washington, D.C., for SPI's Committee on Resin Statistics (CRS)

The Society of the Plastics Industry, Inc.

Resin Statistics

PLASTIC RESINS: 1964 -1989

TOTAL U.S. PRODUCTION AND SALES & CAPTIVE USE *

(millions of pounds)

YEAR	PRODUCTION (Including Polyurethane)	SALES & CAPTIVE USE (Including Polyurethane)
[a]1964	10,525	8,847
1965	12,219	11,035
1966	14,199	11,726
1967	14,473	12,284
1968	17,231	15,396
1969	19,720	16,495
1970	20,056	17,494
1971	21,161	19,813
1972	26,475	25,504
1973	29,213	28,719
1974	29,274	27,890
1975	22,828	22,278
1976	29,196	28,379
1977	33,948	32,771
1978	37,605	36,818
1979	41,577	40,607
1980	37,347	36,896
1981	39,867	38,801
1982	36,607	36,639
1983	42,777	42,212
1984	46,336	45,221
1985	47,946	47,470
[d]1986	50,849	50,452
1987	55,751	55,818
1988	59,762	58,554
1989	59,529	59,676

[a] U.S. Tariff Commission data used for 1964-1970. May exclude some captive use.

[b] Cellulosics included beginning in 1964.

[c] SPI data used for 1971-1989.

[d] 1986-1989 includes SPI Estimates.

COMPOUND GROWTH RATE

Years	Total Production	Sales & Captive Use
1964-1989	7.2%	7.9%
1974-1989	4.8%	5.2%
1979-1989	3.6%	3.9%
1984-1989	5.0%	5.7%
1988-1989	-0.4%	1.9%

* Sales and Captive Use is Defined as Merchant Sales and Intra-Company Captive Use.

TOTAL U.S. PLASTICS BY RESIN

PRODUCTION and SALES & CAPTIVE USE

(millions of pounds)

RESIN	1979		1980		1981		1982		1983	
	P	S&CU	P	S&CU	P	S&CU	P	S&CU	P	S&CU
Epoxy	361	332	315	319	336	332	286	301	334	331
Phenolic	1,781	1,732	1,499	1,517	2,333	2,375	2,006	2,060	2,484	2,529
Polyester	1,147	1,152	947	949	997	977	865	851	1,084	1,072
Urea	1,367	1,355	1,165	1,147	1,165	1,139	998	976	1,172	1,167
Melamine	200	192	167	166	179	175	158	155	180	181
Total Selected Thermosets	4,856	4,763	4,093	4,098	5,010	4,998	4,313	4,343	5,254	5,280
ABS	1,191	1,183	920	916	916	900	740	737	NA	NA
SAN	124	126	111	103	107	105	91	85	93	91
HDPE	5,010	4,893	4,405	4,394	4,695	4,683	4,928	5,024	5,691	5,707
LDPE	7,793	7,815	7,291	7,467	7,693	7,516	7,503	7,687	8,041	8,045
Nylon	327	315	274	271	312	288	228	247	321	329
Polypropylene	3,841	3,894	3,648	3,714	3,955	3,888	3,477	3,623	4,434	4,464
Polystyrene	4,005	3,997	3,521	3,518	3,621	3,604	3,191	3,200	3,567	3,606
PVC	6,119	6,138	5,470	5,407	5,707	5,601	5,326	5,455	6,066	6,152
Thermoplastic Polyester	--	--	503	511	610	581	648	619	778	783
Total Selected Thermoplastics	28,410	28,361	26,143	26,301	27,616	27,166	26,132	26,677	28,991	29,177
Total Selected Plastics	33,266	33,124	30,236	30,399	32,626	32,164	30,445	31,020	34,245	34,457
All Other Plastics	8,311	7,483	7,111	6,497	7,241	6,637	6,162	5,619	8,532	7,755
Grand Total	**41,577**	**40,607**	**37,347**	**36,896**	**39,867**	**38,801**	**36,607**	**36,639**	**42,777**	**42,212**

COMPOUND GROWTH RATE 1979-1989

SALES & CAPTIVE USE

Epoxy	3.8%
Phenolic	**
Polyester	1.1%
Urea	0.8%
Melamine	1.0%
Total Selected Thermosets	**
ABS	0.3%
SAN	-1.5%
HDPE	5.3%
LDPE	3.2%
Nylon	6.3%
Polypropylene	6.5%
Polystyrene	2.4%
PVC	3.2%
Thermoplastic Polyester	NA
Total Selected Thermoplastics	4.5%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

TOTAL U.S. PLASTICS BY RESIN

PRODUCTION and SALES & CAPTIVE USE (Cont'd)

(millions of pounds)

1984		1985		1986		1987		1988		1989	
P	S&CU	P	S&CU	P	S&CU	P	S&CU	P	S&CU	P	S&CU
406	379	385	367	398	375	433	419	486	468	510	482
2,502	2,510	2,621	2,640	2,735	2,771	2,869	2,871	3,066	3,073	2,879	2,863
1,232	1,231	1,223	1,233	1,271	1,265	1,367	1,362	1,404	1,393	1,319	1,302
1,199	1,189	1,210	1,203	1,271	1,266	1,382	1,368	1,425	1,350	1,477	1,465
210	197	192	194	173	191	212	198	207	203	222	213
5,549	5,506	5,631	5,637	5,848	5,868	6,263	6,218	6,588	6,487	6,407	6,325
1,128	1,098	1,028	1,016	1,092	1,080	1,175	1,208	1,277	1,279	1,260	1,217
99	88	87	84	92	87	126	127	148	146	113	108
6,085	5,949	6,671	6,651	7,182	7,028	7,995	8,155	8,400	8,084	8,102	8,173
8,413	8,416	8,889	8,790	8,903	8,799	9,599	9,611	10,397	10,177	9,695	10,803
396	389	399	403	465	443	507	499	566	574	569	580
4,940	4,816	5,139	5,275	5,812	5,824	6,647	6,720	7,274	7,088	7,238	7,303
3,838	3,836	4,054	4,108	4,470	4,463	4,780	4,860	5,187	5,027	5,104	5,131
6,760	6,798	6,772	6,720	7,256	7,412	7,971	8,081	8,350	8,287	8,478	8,493
899	859	965	956	1,175	1,160	1,394	1,410	1,652	1,643	1,630	1,707
32,558	32,249	34,004	34,003	36,447	36,296	40,194	40,671	43,251	42,305	42,189	43,515
38,107	37,755	39,635	39,640	42,295	42,164	46,457	46,889	49,839	48,792	48,596	49,840
8,229	7,466	8,311	7,830	8,554	8,288	9,294	8,929	9,923	9,762	9,933	9,836
46,336	**45,221**	**47,946**	**47,470**	**50,849**	**50,452**	**55,751**	**55,818**	**59,762**	**58,554**	**58,529**	**59,676**

COMPOUND GROWTH RATE 1979-1989

SALES & CAPTIVE USE (Cont'd)

Total Selected Plastics	4.1%
All Other Plastics*	2.8%
Grand Total	**3.9%**

P = Production S & C = Sales & Captive Use NA = Not Available

**Not applicable since reporting on gross weight basis begun in 1981

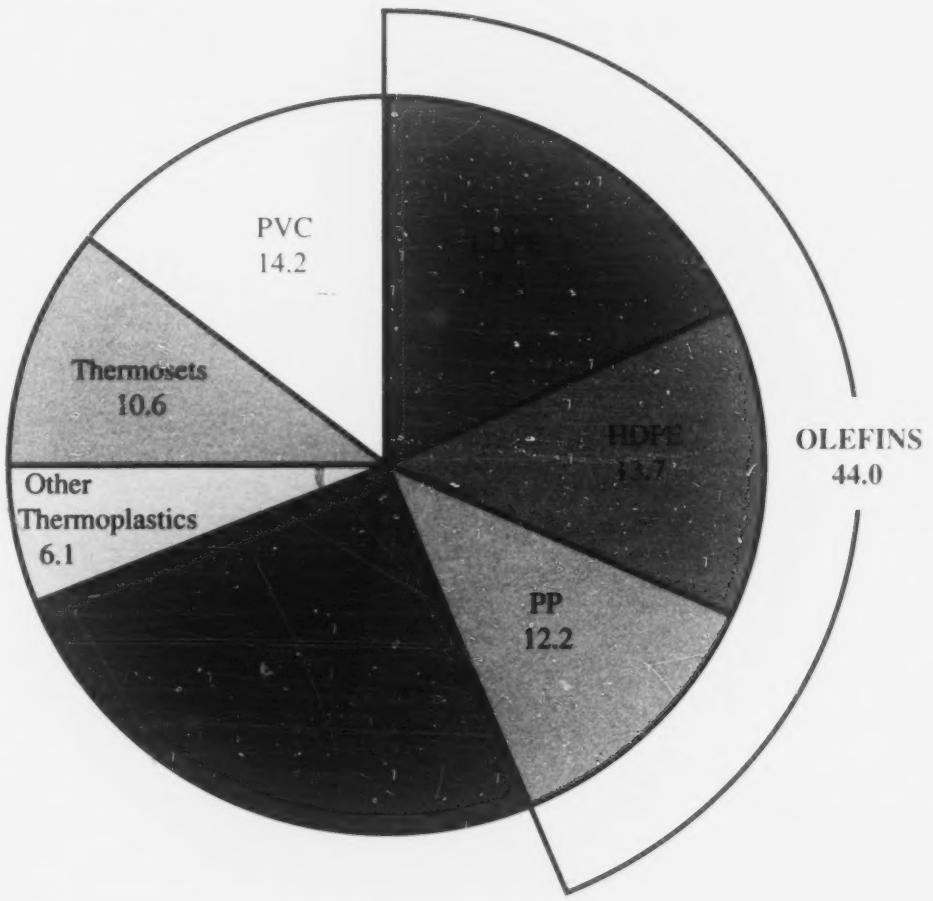
* 1986 - 1989 Includes SPI Estimates

The following resins include some imports in the numbers reported for Sales & Captive Use: LDPE, Nylon and Thermoplastic Polyester.

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

PERCENTAGE DISTRIBUTION OF PLASTIC

SALES & CAPTIVE USE BY MATERIAL



PLASTIC RESINS

DOMESTIC MERCHANT SALES

(millions of dollars and millions of pounds)

Resin	1989		1988		% Change	
	Net Dollar Value	Quantity	Net Dollar Value	Quantity	Net Dollar Value	Quantity
Low Density Polyethylene	$ 3,985	8,969	$ 4,151	8,544	-4.0	5.0
Polyvinyl Chloride	2,815	6,928	2,874	7,085	-2.1	-2.2
High Density Polyethylene	2,989	6,892	3,294	7,147	-9.3	-3.6
Polystyrene	2,319	4,257	2,689	4,202	-13.8	1.3
Polypropylene	2,068	5,057	2,289	4,903	-9.7	3.1
ABS	1,013	1,085	962	1,069	5.3	1.5
Other Styrenes	799	1,131	874	1,129	-8.6	0.2
Unsaturated Polyester	835	1,224	779	1,315	7.2	-6.9
Thermoplastic Polyester	1,142	1,405	1,044	1,414	9.4	-0.6
Nylon	707	474	666	444	6.2	6.8
Phenolic	619	2,526	540	2,886	14.6	-12.5
Epoxy	482	396	472	376	2.1	5.3
Other Vinyls	161	87	155	92	3.9	-5.4
Urea	234	1,447	216	1,320	8.3	9.6
Melamine	174	187	178	189	-2.2	-1.1
SAN	50	69	51	69	-2.0	0.0
Engineering Resins	1,854	1,061	1,352	688	37.1	54.2
Total	$ 22,246	43,195	$ 22,586	42,872	-1.5	0.8

Domestic merchant sales are quantities of sales excluding interplant transfers, captive consumption and exports.
Net dollar value represents the actual selling price after deductions for cash discounts, quantity discounts, returned goods and allowances, federal excise taxes, local taxes, and outgoing transportation (prepaid or otherwise) to warehouses or customers.

Source: SPI Committee on Resin Statistics, as compiled by Ernst & Young

Resin Statistics

APPARENT U.S. CONSUMPTION OF SELECTED PLASTIC RESINS

Apparent consumption is calculated by adding imports to production then subtracting exports. It is a measure of the quantity of material actually consumed in the United States.

For purposes of the table below, the production figures were taken from SPI's Monthly Statistical Report, as compiled by Ernst & Young. Both the import and export figures were taken from Bureau of the Census reports.

1989

(millions of pounds)

RESIN	Production (plus)	Imports (minus)	Exports (equals)	Apparent Consumption	Import % Of Apparent Consumption
Low Density Polyethylene	10,487	889	1,038	10,338	9
High Density Polyethylene	8,102	125	1,130	7,097	2
PVC	8,478	55	803	7,730	1
Polypropylene	7,238	49	1,414	5,873	1
Polystyrene	5,103	63	330	4,836	1
Phenolic	2,879	40	65	2,854	1
Styrene Copolymers (inc. ABS)	2,508	95	379	2,224	4
Thermoplastic Polyester[a]	1,630	46	342	1,334	3
Urea	–1,476	24	15	1,485	2
Unsaturated Polyester	1,320	6	93	1,233	1
Nylon	569	58	169	458	13
Epoxy	509	13	86	436	3
Melamine	222	6	12	216	3
Other Vinyls	NA	NA	NA	NA	NA
1989 TOTAL	**50,521**	**1,469**	**5,876**	**46,114**	**3**
1988 Total	51,201	1,422	5,171	47,452	3
1987 Total	47,898	1,334	4,764	44,468	3
1986 Total	43,595	1,308	3,965	40,938	3
1985 Total	40,836	1,205	3,552	38,489	3
1984 Total	39,293	899	3,484	36,708	2
1983 Total	37,145	581	3,767	33,959	2
1982 Total	31,262	268	4,102	27,428	1
1981 Total	33,696	307	3,596	30,407	1
1980 Total	31,247	247	4,194	27,300	1
1979 Total	34,550	273	3,625	31,198	1
1978 Total	31,101	234	2,302	29,033	1

[a]Not included in total 1978-1979

Source: Production--SPI Monthly Statistical Report, as compiled by Ernst & Young
Imports--Bureau of the Census, IM 145
Exports--Bureau of the Census, EM 545

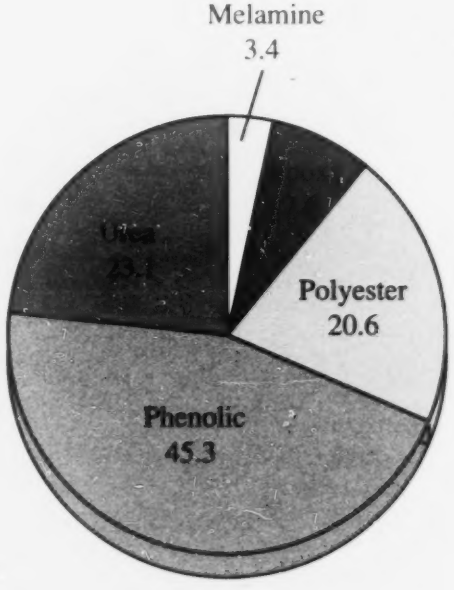
The Society of the Plastics Industry, Inc.

Thermoset Resins

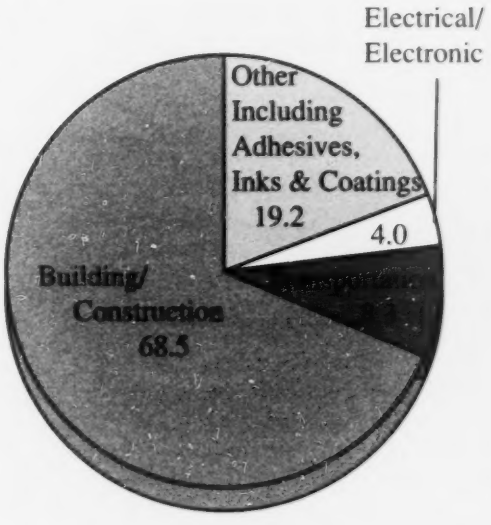
SUMMARY STATISTICS

Plastics which in their final state as finished articles are substantially infusible and insoluable. They are often liquids at some state of their manufacture or processing, which are cured by heat, catalysts or other chemical means. After being fully cured, thermosets cannot be resoftened by heat.

1989 PERCENT OF THERMOSET SALES & CAPTIVE USE



1989 PERCENT BY MATERIAL



1989 PERCENT BY MAJOR MARKET

NOTE: Includes data from reporting companies only. No estimates are included.

Source: SPI Major Market Report, SPI Comittee on Resin Statistics as compiled by Ernst & Young

EPOXY

MANUFACTURERS*

Ciba-Geigy Corp.
Dow Chemical U.S.A
Hi-Tek Polymers
Reichhold Chemicals, Inc.
Rogers Corp.
Shell Chemical Co.
Union Carbide Corp.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1989.

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1979	361	332
1980	315	319
1981	336	332
1982	286	301
1983	334	331
1984	406	379
1985	385	367
1986	398	376
1987	433	419
1988	486	468
1989	509	482
Average Annual Growth		
1979-1989	3.5%	3.8%

DOMESTIC CONSUMPTION BY END-USE

(millions of pounds)

END-USE	1985	1986	1987	1988	1989
Bonding & adhesives	17	19	22	23	25
Flooring, paving and aggregates	17	19	21	25	25
Protective coatings	168	160	171	179	192
Fiber reinforced laminates & composites	69	69	72	83	83
Tooling, casting, and molding resins	23	23	24	27	30
All other cases	31	29	34	39	41
Total	**325**	**319**	**344**	**376**	**396**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

EPOXY

DISTRIBUTION BY MAJOR MARKET

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989
Transportation	*	*	*	*	*
Packaging	*	*	*	5	6
Building and Construction	39	38	47	51	43
Electrical/Electronic	72	80	74	89	87
Furniture and Furnishings	*	*	*	8	*
Consumer and Institutional	*	*	*	4	*
Industrial/Machinery	*	*	*	*	*
Adhesives/Inks/ Coatings	140	140	148	*	*
All Other	74	61	69	219	260
Exports	42	57	75	92	86
Total	**367**	**376**	**419**	**468**	**482**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Coatings
Electrical laminates
Floor/paving aggregates
Reinforced composites
Electrical/Electronic casting
Industrial equipment
Adhesives and molding
Sealants

PHENOLIC

MANUFACTURERS*

Allied
Ametek, Haveg Div.
Ashland Chemical Co.
BASF (Inmont Div.)
Borden, Inc.
BTL Corp.
Chembond Corp.
Formica Corp.
Georgia-Pacific Corp.
Hoechst Celanese
Masonite Corp.
Occidental Chemical Corp.
Owens-Corning Fiberglas Corp.
Plaslok Corp.
Plastics Engineering Co.
Rogers Corp.
Sterling Engineered Products
Stuart-Ironsides, Inc.
Union Carbide Corp.
Valite Div., Valentine Sugars, Inc.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1989

PRODUCTION AND SALES & CAPTIVE USE[1]

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1979	1,781	1,732
1980	1,499	1,517
1981	2,333	2,375
1982	2,006	2,060
1983	2,484	2,529
1984	2,502	2,510
1985	2,621	2,640
1986	2,735	2,771
1987	2,869	2,871
1988	3,066	3,073
1989	2,879	2,863
Average Annual Growth		
1981-1989	2.6%	2.4%

[1] Gross weight basis of reporting began in 1981 therefore data are not comparable before then.

TYPICAL APPLICATIONS

Wiring devices
Connectors
Transmission parts
Pulleys
Electrical switch gear
Closures
Handles
Telephone relay systems
Rubber tackifiers
Laminating plywood
Knobs
Power brake components

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

PHENOLIC

DOMESTIC CONSUMPTION BY END-USE

(millions of pounds)

END-USE	1985	1986	1987	1988	1989
Molding compounds	209	206	195	190	177
Bonding & adhesive resins for:					
Laminating	142	200	191	217	215
Coated & bonded abrasives	16	19	20	23	24
Friction materials	26	29	32	38	41
Insulation materials	419	425	435	503	415
Foundry & shell molding	77	42	44	53	60
Plywood	1,255	1,450	1,558	1,582	1,416
Fibrous & granulated wood	217	244	247	*	*
Resins sold to Rubber Industry	28	31	18	19	14
All other	159	66	35	328	437
Protective coatings	23	24	24	21	13
All other uses	48	20	54	77	31
Total	**2,619**	**2,756**	**2,853**	**3,051**	**2,843**

*Included in All Other
Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

DISTRIBUTION BY MAJOR MARKET

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989
Transportation	124	85	63	61	39
Packaging	*	*	*	*	*
Building and Construction	1,950	2,278	2,394	2,612	2,506
Electrical/Electronic	128	130	122	*	*
Furniture and Furnishings	*	*	*	61	*
Consumer and Institutional	*	*	*	*	*
Industrial/Machinery	7	*	*	*	*
Adhesives/Inks/Coatings	82	68	67	52	25
All Other	328	194	207	265	273
Exports	21	16	18	22	20
Total	**2,640**	**2,771**	**2,871**	**3,073**	**2,863**

*Included in All Other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

UNSATURATED POLYESTER

MANUFACTURERS*

Advance Coatings Corp.
Alpha Chemical Corp.
Aristech Chemical Co.
Ashland Chemical Co.
BASF (Inmont Div.)
Cook Paint & Varnish Co.
Dow Chemical U.S.A.
Freeman Chemical Corp.
Glidden Coatings & Resin
Interplastics Corp.
Owens-Corning Fiberglas Corp.
Reichhold Chemicals, Inc.
Sherex Chemical Co., Inc.
SILMAR Div., B.P. America, Inc.
Sterling Engineered Products

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1989

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1979	1,147	1,152
1980	947	949
1981	997	977
1982	865	851
1983	1,084	1,072
1984	1,232	1,231
1985	1,223	1,233
1986	1,271	1,265
1987	1,367	1,362
1988	1,404	1,393
1989	1,319	1,302
Average Annual Growth		
1979-1989	1.4%	1.3%

TYPICAL APPLICATIONS

Panels
Tanks
Auto components
Sanitary fixtures
Synthetic marble
Recreational vehicles
Pleasure boats
Bowling balls
Showerstalls

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

UNSATURATED POLYESTER

MAJOR DOMESTIC MARKETS

(millions of pounds)

	1985	1986	1987	1988	1989
DOMESTIC REINFORCED PLASTICS, TOTAL	**949**	**947**	**1,030**	**1,050**	**950**
Marine and marine accessories	246	265	302	330	290
Transportation	120	107	106	107	95
Auto, trucks, buses, etc.	100	88	89	86	73
Other transportation	20	19	17	21	22
Construction	382	382	445	428	389
General construction	158	145	151	140	109
Bathroom components & fixtures	112	124	160	147	134
Corrosion resistant and General purpose tanks, pipes, etc.	112	113	134	141	146
Electrical generation, transmission and distribution	27	27	26	28	29
Consumer goods	96	84	66	71	63
Major appliances and parts	21	21	20	21	22
Recreational goods, toys, etc.	42	--	23	28	29
Other consumer goods	33	--	23	22	12
Gel coats	38	42	45	48	55
Other reinforced	40	40	40	38	29
DOMESTIC NON-REINFORCED PLASTICS, TOTAL	**276**	**309**	**322**	**327**	**328**
Castings	160	173	184	186	182
Furniture	7	5	5	9	5
Cultured marble & onyx	107	121	131	128	133
Other	46	47	48	49	44
Autobody putty	61	69	72	66	68
Surface and protective coatings	6	8	8	15	10
Bonding and adhesives	2	4	2	3	*
Minebolt anchor resins	20	NA	26	26	*
Other non-reinforced	27	55	30	31	68

DISTRIBUTION BY MAJOR MARKET

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989
Transportation	411	428	472	397	463
Packaging	--	--	*	*	*
Building/Construction	487	505	541	491	488
Electrical/Electronic	61	59	48	40	39
Furniture/Furnishings	11	11	22	31	17
Consumer & Instititutional	60	70	98	132	123
Industrial/Machinery	*	24	*	20	2
Adhesives, Inks & Coatings	*	*	*	14	19
All Other	194	159	171	252	127
Exports	9	9	10	16	24
Total	**1,233**	**1,265**	**1,362**	**1,393**	**1,302**

NA = Not Available *Included in all other

Sources: Quarterly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young
SPI Committee on Resin Statistics Annual Major Markets Survey

UREA

MANUFACTURERS*

Air Products & Chemicals, Inc.
Borden Chemical Co.
BTL Corp.
Chembond Corp.
Georgia-Pacific Corp.
Grifftex Chemicals, Inc.
Harborchem, Inc.
Hi-Tek Polymers
Monsanto Co.
Perstorp Compounds, Inc.
Reichhold Chemicals, Inc.
Sterling Engineered Products

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1989

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1979	1,367	1,355
1980	1,165	1,147
1981	1,165	1,139
1982	998	976
1983	1,172	1,167
1984	1,199	1,189
1985	1,210	1,203
1986	1,271	1,266
1987	1,382	1,368
1988	1,425	1,350
1989	1,476	1,465
Average Annual Growth		
1979-1989	0.8%	0.8%

Sources: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

MELAMINE

MANUFACTURERS*

American Cynamid Co.
Borden Chemical Co.
BTL Corp
Chembond Corp.
Formica Corp.
Grifftex Chemicals, Inc.
Harborchem, Inc.
Hi-Tek Polymers
Hoechst Celanese
Monsanto Co.
Owens-Corning Fiberglas
Perstorp Compounds, Inc.
Reichhold Chemicals, Inc.
Sterling Engineered Products

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1989

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1979	200	192
1980	167	166
1981	179	175
1982	158	155
1983	180	181
1984	210	197
1985	192	194
1986	173	191
1987	212	198
1988	207	203
1989	222	213
Average Annual Growth		
1979-1989	1.1%	1.0%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

UREA AND MELAMINE

DOMESTIC CONSUMPTION BY END-USE

(millions of pounds)

END-USE	1985	1986	1987	1988	1989
Textile treating & coating resins	17	21	24	28	25
Paper treating & coating resins	100	97	80	54	63
Bonding & adhesive resins for:					
Laminating	45	45	51	42	72
Plywood	57	60	58	50	67
Fibrous & granulated wood	955	1,029	1,128	1,152	1,205
Protective coatings	89	102	110	111	108
All other uses	134	102	115	115	138
Total	**1,397**	**1,456**	**1,566**	**1,552**	**1,678**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

DISTRIBUTION BY MAJOR MARKET

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989
Transportation	*	*	*	*	*
Packaging	30	33	31	36	42
Building and Construction	1,009	1,093	1,193	212	1,297
Electrical/Electronic	*	*	*	*	*
Furniture and Furnishings	43	37	38	21	29
Consumer and Institutional	116	*	*	*	*
Industrial/Machinery	--	--	--	--	--
Adhesives/Inks/Coatings	*	*	*	*	*
All Other	199	294	304	283	310
Exports	*	*	*	*	*
Total	**1,397**	**1,457**	**1,566**	**1,552**	**1,678**

*Included in All Other
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

UREA		MELAMINE	
Wiring devices	Buttons	Adhesives and bonding	Dinnerware
Toilet seats	Knobs	Buttons	Knobs
Handles	Adhesives and bonding	Handles	Ashtrays

ISOCYANATES

MANUFACTURERS*

BASF Corporation
Dow Chemical U.S.A.
ICI Americas, Inc.
Mobay Corporation
Olin Corporation

*Those manufacturers who participated in the SPI Monthly Isocyanates Report in 1989.

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

Production

Year	TDI	MDI	TOTAL
1985	629	683	1,312
1986	654	692	1,346
1987	705	829	1,534
1988	741	935	1,676
1989	735	927	1,662

Sales & Captive Use

Year		TDI	MDI	TOTAL
1985	**TOTAL**	**628**	**666**	**1,294**
	Domestic	499	540	1,039
	Export	129	126	255
1986	**TOTAL**	**654**	**695**	**1,349**
	Domestic	498	572	1,070
	Export	156	123	279
1987	**TOTAL**	**702**	**814**	**1,516**
	Domestic	552	641	1,193
	Export	150	173	323
1988	**TOTAL**	**742**	**904**	**1,646**
	Domestic	574	700	1,274
	Export	168	204	372
1989	**TOTAL**	**724**	**923**	**1,647**
	Domestic	541	717	1,258
	Export	183	206	389

Source: Monthly Isocyanates Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

POLYETHER POLYOLS

MANUFACTURERS*

ARCO Chemical Co.
BASF Corporation
Choate Chemical
Dow Chemical Company
E.I. duPont de Nemours & Co.
Mobay Chemical Co.
Olin Corp.
Q.O. Chemical
Stepan Corporation
Union Carbide Corp.
Witco Chemical Corp.

*Those manufacturers who participated in the SPI Monthly Polyols Report in 1989

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds) **

	Production	Sales & Captive Use				
Year		Total	Flexible Foam	Rigid Foam	Non-Foam	Export
1985	1,391	1,407	1,014	133	141	119
1986	1,452	1,453	1,000	127	158	168
1987	1,626	1,653	1,045	144	188	276
1988	1,872	1,918	1,134	138	232	414
1989	1,808	1,786	1,048	132	256	350

** Dry Weight Basis

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

POLYESTER POLYOLS

MANUFACTURERS*

Brinmont Chemicals, Inc.
Chemical Exchange Industries
Dow Chemical, U.S.A.
Freeman Chemical - Chardenol Division
Hercules, Inc.
Inolex Chemical Company
Mobay Chemical Corporation
Stepan Company
Sterling Engineered Products
Union Carbide Corporation
Uniroyal, Chemical Division
Witco Chemical

*Those manufacturers who participated in the Quarterly Polyester Polyols Report in 1989

PRODUCTION AND SALES & CAPTIVE USE

(thousands of pounds) **

	Production		Sales & Captive Use	
Year	Aliphatic[1]	Aromatic[2]	Aliphatic[1]	Aromatic[2]
1985	40,712	NA	40,223	NA
1986	46,764	NA	46,362	NA
1987	55,653	124,147	54,790	122,916
1988	57,855	144,559	56,843	143,076
1989	59,443	134,433	58,528	134,580

[1] Excludes Polyesters for foam, includes Caprolactones
[2] Includes Rigid Foam
NA = Not Available
** Dry Weight Basis

Source: Quarterly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

POLYURETHANE

RAW MATERIALS - 1989[1]

(millions of pounds)

RAW MATERIAL	Flexible Foam	Rigid Foam	Coatings	Adhesives & Sealants	Elastomers	TOTAL
TDI	501	13	20	20	5	**559**
MDI	24	491	8	47	92	**662**
Aliphatic DI	-	-	27	-	2	**29**
Polyether	1,075	141	28	92	137	**1,473**
Polyester	50	131	27	4	37	**249**
Other[2]	85	94	70	35	39	**323**
Total Product	**1,735**	**870**	**180**	**198**	**312**	**3,295**

[1] Calculated data does not agree exactly with primary SPI data shown.
[2] Includes blowing agent, catalyst, surfactant, colorant/pigment, fire retardant, fillers and other additives.

DOMESTIC MARKETS - 1989

(millions of pounds)

	Foam		Non-Foam			
INDUSTRY	Flexible	Rigid	Coatings	Adhesives & Sealants	Elastomers	TOTAL
Construction	-	480	60	32	-	**572**
Transportation	532	38	35	23	125	**753**
Furniture	607	14	6	-	10	**637**
Carpet[1]	300	-	-	40	-	**340**
Appliance	-	151	9	-	-	**160**
Packaging	40	68	-	20	15	**143**
Bedding	175	-	-	-	-	**175**
Other[2]	81	119	70	83	162	**515**
Total	**1,735**	**870**	**180**	**198**	**312**	**3,295**

[1]Additional pounds of scrap were generated in other industry segments, and were used in rebond carpet underlay, but were not included to avoid double counting.
[2]Includes textiles/fibers, marine, tank/pipe, footwear, electronic, machinery, wheels & tires, foundry, etc.

Source: SPI Polyurethane Division, as prepared by Hull & Co.

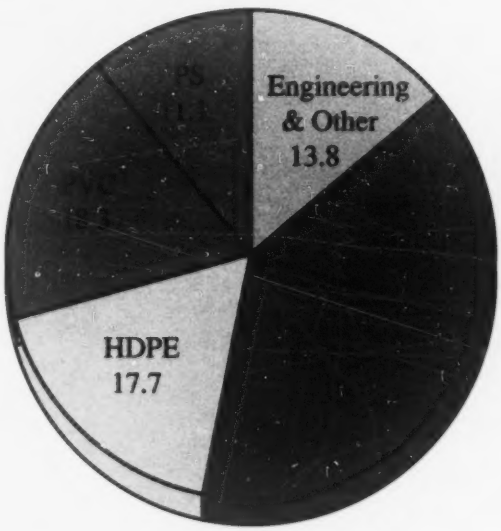
The Society of the Plastics Industry, Inc.

Thermoplastic Resins

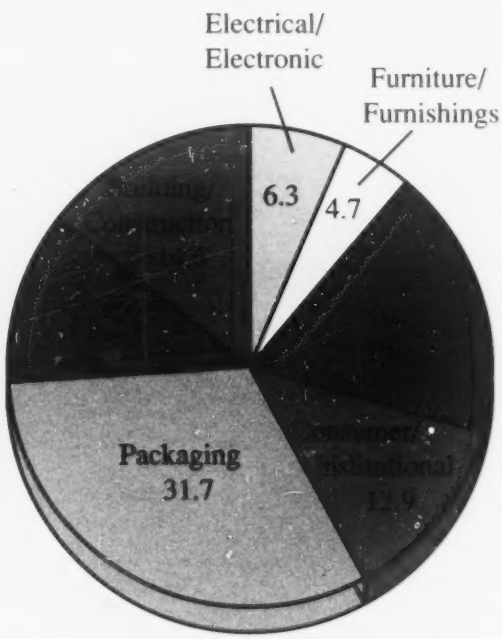
SUMMARY STATISTICS

Thermoplastic resins are plastics which are capable of being repeatedly softened by heat and hardened by cooling in their final form as finished articles.

1989 THERMOPLASTIC SALES & CAPTIVE USE



**1989
PERCENT
BY RESIN MATERIAL**



**1989
PERCENT
BY MAJOR MARKET**

NOTE: Includes data from reporting companies only. No estimates are included.

Source: SPI Major Market Report, SPI Committee on Resin Statistics as compiled by Ernst & Young.

Thermoplastic Resins

LATEX MATERIAL

Latex materials (sometimes referred to as emulsion polymers) are dispersions of the plastic polymer particles in water. Developed in the laboratory in the early 1930's, the first successful product was a synthetic rubber latex, commercialized during World War II to supplement the short supply of natural rubber latex.

A great variety and profusion of emulsions are now in commercial production. The most important of the plastic latexes are copolymers of styrene and butadiene, homopolymers and copolymers of vinyl acetate, acrylates, and vinyl chloride, as well as emulsions of polyvinyl chloride, and other specialties. Other co-monomers used include fumarate, maleate, and ethylene.

The non-plastic synthetic rubber latices, excluded from SPI statistics, are elastomers categorized as Styrene/Butadiene (high butadiene), Polybutadiene, Acrylonitrile/Butadiene, Chloroprene, and Butyl. There is a significant amount of inter-product competition, particularly among the plastic types, and further there is competition with the synthetic and natural rubber latices which historically have been used.

The major end-uses for these plastic latex materials lie in four areas: (1) Adhesives - primarily in the packaging, construction, and wood products areas; (2) Coatings - primarily as a vehicle in waterbased paints; (3) Paper - primarily as a clay coatings binder, but also used for saturating; and (4) Textiles - primarily as fabric finishes, sizes, back coats, and in fabric lamination and non-woven fiber bonding.

The emulsions and compounds are generally sold or used in relatively small batches (drums, tank trucks, and tank cars), and in many applications the emulsions are tailor-made to the end-use. There are thousands of end-users, some of whom polymerize for themselves, some of whom buy compounded material.

Each product sold has some unique characteristic desired in the end-use. For example, some adhesive resins should impart water resistance, fabric resins should be hard or soft depending on the type desired, and coatings resins should have good tint retention properties.

As a class these plastic emulsions have gained wide acceptance in the above mentioned end-uses for one or more of the following reasons:

- Water base (will meet the requirements of air pollution controls and regulations)
- Ease of clean-up
- Good adhesion to various substrates
- High pigment binding capacity
- Abrasion resistance and flexibility
- Uniform quality as compared with natural binders
- Good supply picture as compared with many of the natural binders
- Relative low cost versus binding efficiency
- Compatibility with existing technology and processes

STYRENE BUTADIENE & OTHER STYRENE BASED LATEXES

Significant producers are: BASF Corp.,Dow Chemical USA, GenCorp Polymer Products, Goodyear Chemical Div., Morton Industries, Reichhold Chemicals and Union Chemical.

PRODUCTION AND SALES & CAPTIVE USE
(thousands of pounds)

		SALES & CAPTIVE USE*				
Year	Production	Paper Treating	Textile Treating	Carpet Backing	All Other	Total
1985	736,163	39,064	17,026	304,370	429,609	790,069
1986	823,305	55,722	20,438	315,581	475,572	867,313
1987	929,364	46,256	16,480	364,371	543,200	970,307
1988	956,311	29,584	11,343	379,156	574,635	994,718
1989	997,362	28,372	11,082	379,220	609,323	1,027,997

* Data may not be comparable due to variations in participation

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as compiled by Ernst & Young

ABS AND SAN

MANUFACTURERS*

BASF Corp.
B.F. Goodrich Chemical Co.
Dow Chemical U.S.A.
G.E. Plastics Co.
Monsanto Company
W.R. Grace & Co.

*Those companies who participated in the SPI Monthly Statistical Report in 1989

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION		SALES & CAPTIVE USE	
	ABS	SAN	ABS	SAN
1979	1,191	124	1,183	126
1980	920	111	916	103
1981	916	107	900	105
1982	740	91	737	85
1983	NA	93	NA	91
1984	1,128	99	1,098	88
1985	1,028	87	1,016	84
1986	1,092	92	1,080	87
1987	1,175	126	1,208	127
1988	1,277	148	1,279	146
1989	1,260	113	1,217	108
Average Annual Growth				
1979-1989	0.8%	-0.9%	0.3%	-1.5%

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

ABS AND SAN

DISTRIBUTION OF ABS AND SAN BY MAJOR MARKET

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989
Transportation	269	285	*	314	338
Packaging	*	5	*	3	*
Building and Construction	134	133	*	147	*
Electrical/Electronic	241	261	*	*	*
Furniture and Furnishings	*	*	*	*	*
Consumer and Institutional	*	*	*	259	*
Industrial/Machinery	*	*	*	*	*
Adhesives/Inks/Coatings	*	*	*	*	--
All Other	456	484	1,136	702	987
Exports	*	*	199	*	--
Total	**1,100**	**1,168**	**1,335**	**1,425**	**1,325**

* Included in All Other

TYPICAL APPLICATIONS

ABS		SAN	
Household appliances	Business machines	Automotive trim	Boat hulls
Telephones	Refrigerator liners	Marine instruments	Solar collectors
Bath tubs	Sporting goods	Tractor components	Swimming pool components
Automotive trim			

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

ENGINEERING THERMOPLASTIC RESINS

Engineering resins are characterized by a combination of high ratings for mechanical, thermal, electrical, and chemical properties. Fillers such as glass, carbon, metallic oxides, metallic powders, calcium carbonate, and silica products, and reinforcements such as fibrous glass, carbon, and other inorganic and organic fibers are added to improve these properties.

The following resins are generally considered to be included in the category of engineering resins: fluoropolymers; polyimides and polyamide-imides; modified polyphenylene oxide; polyphenylene sulfide; thermoplastic polyester resin; polycarbonate; polysulfone; and acetal. Other materials which may be used in similiar applications such as ABS, SAN, and nylon are mentioned elsewhere in Facts & Figures.

TYPICAL APPLICATIONS

Acetal (AC)	Fasteners, knobs, bushings, bearings, faucets, valves, seat belt components, conveyor belts, zippers, disposable lighter bodies.
Fluoropolymers	Wire & cable jacketing, nonstick coatings, bearing pads, laminates.
Polycarbonate (PCO)	Microwave cookware, filter housings, bottles, lamp housings, drapery fixtures, safety glazing, nameplates, food processor bowls.
Polyphenylene Sulfide (PPS)	Pumps, hair dryers, small cooking appliances, automotive components.
Thermoplastic Polyester (TP)	Lighting, microwave cookware, bearings, beverage bottles, food containers, auto grilles, switches.
Polysulfone (PSO)	Food processing equipment, circuit boards, camera and watch cases, purification devices, connectors.
Modified Polyphenylene Oxide(PPO)	Personal computers, auto instrument panels, wheel covers, pump housings, radomes, fuse boxes, TV cabinetry.
Polyimide (PI)	Printed wiring boards, gears, electric motors, radomes, bearings.
Polyamide-imide (PAI)	Seals, valve train components, jet engine components, transmissions.

ENGINEERING THERMOPLASTIC RESINS

MANUFACTURING

KNOWN MANUFACTURERS	AC	PCO	PPS	TP	PSO	PPO	PI	PAI	FLUORO-POLYMERS
Allied				X					
Amoco Chemical					X		X	X	
Ausimont									X
BASF Corp.				X					
Dow Chemical		X							
DuPont	X			X			X		X
Eastman Chemical				X					
General Electric		X		X		X	X		
Goodyear				X					
Hoechst Celanese	X			X					
ICI Americas				X					X
Mobay Chemical		X							
ATOCHEM									X
Phillips 66 Co.			X						

PRODUCTION AND SALES & CAPTIVE USE[1]

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE	COMPOUND GROWTH RATE OF SALES & CAPTIVE USE	
1979	729	709	1979-1989	6.8%
1980	673	645	1984-1989	9.0%
1981	676	633	1984-1985	-6.0%
1982	569	596	1985-1986	0.1%
1983	731	781	1986-1987	13.9%
1984	878	892	1987-1988	37.7%
1985	834	839	1988-1989	4.6%
1986	877	840		
1987	1,036	957		
1988	1,342	1,318		
1989	1,419	1,378		

DISTRIBUTION BY MAJOR MARKET[1]

(millions of pounds)

MAJOR MARKET	1984	1985	1986	1987	1988	1989
Transportation	136	140	*	*	*	*
Packaging	2	14	15	18	22	*
Building & Construction	101	79	84	82	*	50
Electrical/Electronic	305	250	236	*	*	*
Consumer/Institutional	90	28	31	63	91	81
Industrial/Machinery	88	37	43	37	45	42
Other	70	88	244	541	883	915
Exports	100	203	187	215	276	290
Total	**892**	**839**	**840**	**956**	**1,318**	**1,378**

Source: SPI Committee on Resin Statistics as compiled by Ernst & Young

[1] Excludes Thermoplastic Polyester resins

* Included in other

HIGH DENSITY POLYETHYLENE

MANUFACTURERS*

Allied Chemical Co.	Himont U.S.A.	Phillips Chemical Co.
Chevron Chemical Co.	Hoechst Celanese	Quantum Chemical Corp.
Dow Chemical USA	Mobil Chemical Co.	Soltex Polymers
Exxon Chemical Americas	Occidental Chemical Co.	Union Carbide Corp.

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1989.

	CAPACITY	UTILIZATION RATE (%)
1979	5,323	94.1
1980	5,921	74.4
1981	5,995	78.3
1982	6,439	76.5
1983	6,888	82.6
1984	7,341	82.9
1985	7,408	90.1
1986	7,301	98.4
1987	7,997	99.9
1988	8,530	98.5
1989	9,081	89.2

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1979	5,010	4,893
1980	4,405	4,394
1981	4,695	4,683
1982	4,928	5,024
1983	5,691	5,707
1984	6,085	5,949
1985	6,671	6,651
1986	7,182	7,028
1987	7,995	8,155
1988	8,400	8,084
1989	8,102	8,173
Compound Growth Rate		
1979-1989	4.9%	5.3%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

HIGH DENSITY POLYETHYLENE

DOMESTIC CONSUMPTION BY END-USE

(millions of pounds)

END-USE	1985	1986	1987	1988	1989
Film (12 mils & below)	437	497	650	736	831
Sheet (over 12 mils)	140	177	231	282	304
Injection molding	1,538	1,550	1,780	1,658	1,451
Wire & cable	113	119	106	125	153
Extrusion coating	NA	NA	NA	NA	*
Blow molding	2,245	2,400	2,884	3,002	2,879
Pipe & conduit	478	444	593	537	486
Other extruded products	36	50	61	87	67
All other uses	787	866	967	1,008	1,079
Total	**5,774**	**6,103**	**7,272**	**7,435**	**7,250**

NA = Not Available

* Included in Other Extruded Products.

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as compiled by Ernst & Young.

DISTRIBUTION BY MAJOR MARKET

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989
Transportation	183	232	213	145	209
Packaging	3,355	3,560	4,325	4,731	4,353
Building and Construction	546	522	775	830	683
Electrical/Electronic	153	147	138	135	155
Furniture and Furnishings	46	*	*	*	*
Consumer and Institutional	507	783	896	659	862
Industrial/Machinery	141	132	159	161	*
Adhesives/Inks/Coatings	--	*	*	25	24
All Other	843	728	766	749	964
Exports	877	924	883	649	923
Total	**6,651**	**7,028**	**8,155**	**8,084**	**8,173**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Grocery bags	Florist tissue	55-gal. drums
Bottles	Cables	Shipping containers
Agricultural tanks	Gasoline tanks	Seating

HIGH DENSITY POLYETHYLENE

SELECTED END-USES

(millions of pounds)

	1985	1986	1987	1988	1989
FILM	**461**	**491**	**648**	**731**	**846**
Millinery/merchandising bags	154	173	224	166	132
Food packaging	121	NA	137	115	143
All other	186	318	287	450	571
INJECTION MOLDING	**1,460**	**1,562**	**1,771**	**1,653**	**1,452**
Industrial and shipping pails[1]	375	433	483	436	432
Housewares[2]	116	166	188	192	99
Crates and totes[1]	179	156	192	218	187
Toys	68	66	52	39	40
Aerosol overcaps, caps, closures	89	70	90	117	99
Food tubs or containers	245	176	271	306	231
All other	388	495	495	345	364
BLOW MOLDING	**2,188**	**2,406**	**2,878**	**3,011**	**2,872**
Liquid food bottles	750	802	886	863	905
Household chemicals	724	813	1,033	965	874
Industrial drums	154	171	219	221	153
Pharmaceuticals, cosmetics & toiletries	NA	174	233	219	227
All other	560	446	507	743	713
ROTOMOLDING	NA	NA	NA	NA	**72**
PIPE AND CONDUIT	**456**	**453**	**592**	**538**	**487**
Corrugated	103	143	162	108	95
Gas distribution	134	120	171	161	140
All other	219	190	259	269	252

NA = Not Available
[1] 5 gallons or less
[2] Includes household pails
[3] Includes beverage cases

Source: SPI Committee on Resin Statistics as compiled by Ernst & Young

LOW DENSITY POLYETHYLENE [1]

MANUFACTURERS*

Chevron Chemical Co.
Dow Chemical U.S.A.[2]
DuPont
DuPont Canada[2]
Eastman Chemical Co.
Esso Chemical Canada[2]
Exxon Chemical Americas
Mobil Chemical Co.
Nova Corp.[2]
Phillips 66 Co.
Quantum Chemical Corp.
Rexene Corp.
Soltex Polymers
Union Carbide Corp.[2]
Westlake Polymers

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1989

	U.S. CAPACITY	UTILIZATION RATE (%)
1979	7,977	97.7
1980	8,471	86.1
1981	9,761	78.8
1982	9,361	80.2
1983	8,655	93.0
1984	9,491	88.6
1985	9,973	89.2
1986	10,086	88.3
1987	10,491	91.5
1988	11,479	90.6
1989	11,938	81.2

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	U.S. PRODUCTION	SALES & CAPTIVE USE
1979	7,793	7,815
1980	7,291	7,467
1981	7,693	7,516
1982	7,503	7,687
1983	8,041	8,045
1984	8,413	8,416
1985	8,899	8,790
1986	8,903	8,799
1987	9,599	9,611
1988	10,397	10,177
1989	9,695	10,803 *
Compound Growth Rate		
1979-1989	2.2%	3.3%

* 1989 data includes sales from imports.

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young
[1] Includes data for Low Density and Linear Low Density Polyethylene.
[2] These companies report data for LD/LLDPE resin produced in Canada, but sold in the U.S.

LOW DENSITY POLYETHYLENE [1]

DOMESTIC CONSUMPTION BY END-USE

(millions of pounds)

END-USE	1985	1986	1987	1988	1989[2]
Film (12 mils & below)	4,777	4,787	5,234	5,514	5,847
Sheet (over 12 mils)	NA	NA	NA	NA	106
Injection molding	583	574	697	758	858
Wire & cable	337	336	337	386	385
Extrusion coating	649	678	768	769	741
Blow molding	47	39	54	76	79
Pipe & conduit	28	32	48	63	61
Other extruded products	103	112	133	180	107
All other uses	1,136	1,301*	1,338*	1,525*	1,497*
Total	**7,660**	**7,859**	**8,609**	**9,271**	**9,681**

*Includes resellers and compounders

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

DISTRIBUTION BY MAJOR MARKET

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989[2]
Transportation	*	*	*	92	105
Packaging	5,469	5,605	6,161	5,929	5,688
Building and Construction	327	213	377	341	418
Electrical/Electronic	403	421	420	*	*
Furniture and Furnishings	37	71	41	48	*
Consumer and Institutional	468	507	610	866	1,611
Industrial/Machinery	*	*	*	272	112
Adhesives/Inks/Coatings	111	231	337	393	307
All Other	844	812	662	1,330	1,440
Exports	1,131	939	1,003	906	1,122
Total	**8,790**	**8,799**	**9,611**	**10,177**	**10,803**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Stretch wrap
Diaper liners
Household cling wrap
Squeeze bottles
Housewares
Lids
Closures
Pipe
Toys

[1] Includes data for Low Density and Linear Low Density Polyethylene.

[2] 1989 data includes sales from imports.

LOW DENSITY POLYETHYLENE[1]

SELECTED END-USES

(millions of pounds)

	1985	1986	1987	1988	1989[2]
PACKAGING FILM	**3,060**	**3,027**	**3,389**	**3,394**	**3,372**
Food Packaging	**970**	**980**	**945**	**1,133**	**1,204**
Produce	156	165	278	228	166
Bakery	292	356	370	378	334
All other food packaging	522	459	297	527	704
Non-Food Packaging	**1,756**	**1,674**	**1,929**	**1,721**	**1,684**
Industrial liners	833	696	712	564	551
Shipping sacks	253	262	351	287	275
All other non-food packaging	670	716	866	870	858
Pallet Shrink Film	*	**98**	*	*	**60**
All Other Shrink Film	**334**	**33**	**215**	**202**	**84**
Stretch Film	*	**243**	**300**	**338**	**340**
NON-PACKAGING FILM	**1,687**	**1,723**	**1,801**	**2,190**	**2,473**
Trash bags	1,125	976	994	1,060	1,256
Construction and agriculture	123	118	230	226	154
Disposable diapers	NA	134	201	196	198
All other non-packaging film	439	495	376	708	865
INJECTION MOLDING	**551**	**581**	**694**	**761**	**864**
Lids	124	148	194	241	263
Toys and novelties	17	31	28	9	23
Housewares	192	221	271	265	207
All other injection molding	218	181	201	246	371
EXTRUSION COATING	**593**	**708**	**768**	**777**	**741**
Paperboard	300	367	443	373	345
All other extrusion coating	293	341	325	404	396
WIRE AND CABLE	**NA**	**338**	**337**	**386**	**385**
ROTOMOLDING RESINS	**NA**	**89**	**157**	**162**	**259**

NA = Not available

* in all other shrink film

Source: SPI, Committee on Resin Statistics as compiled by Ernst & Young.

[1] Includes data for Low Density and Linear Low Density Polyethylene.

[2] 1989 data includes sales from imports.

LOW DENSITY POLYETHYLENE[1]

MANUFACTURERS*

Chevron Chemical Co.
Dow Chemical U.S.A.
DuPont
Eastman Chemical Co.
Exxon Chemical Americas
Mobil Chemical Co.
Nova Plastics
Quantum Chemical Corp.
Rexene Corp.
Union Carbide Corp.
Westlake Polymers

* Those manufacturers who participated in the SPI Monthly Statistical Report in 1989.

	U.S. CAPACITY	UTILIZATION RATE (%)
1989	7,769	84.6

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	U.S. PRODUCTION	SALES & CAPTIVE USE[2]
1989	6,575	6,916

DOMESTIC CONSUMPTION BY END-USE

(millions of pounds)

END-USE	1989[2]
Film (12 mils & below)	3,444
Sheet (over 12 mils)	79
Injection molding	413
Wire & cable	*
Extrusion coating	*
Blow molding	60
Pipe & conduit	*
Other extruded products	1,066
All other uses (incl. Resellers & Compounders)	906
Total	**5,968**

*Included in Other extruded products

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young.

[1] Data does not include Linear Low Density Polyethylene.

[2] Data includes sales from imports.

LINEAR LOW DENSITY POLYETHYLENE[1]

MANUFACTURERS*

Dow Chemical U.S.A.
DuPont Canada
Esso Chemical Canada
Exxon Chemical Americas
Mobil Chemical Co.
Nova Plastics
Phillips 66 Co.
Quantum Chemical Corp.
Soltex Polymers
Union Carbide Corp.

* Those manufacturers who participated in the SPI Monthly Statistical Report in 1989.

	U.S. CAPACITY	UTILIZATION RATE (%)
1989	4,169	74.8

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	U.S. PRODUCTION	SALES & CAPTIVE USE[2]
1989	3,120	3,887

DOMESTIC CONSUMPTION BY END-USE

(millions of pounds)

END-USE	1989[2]
Film (12 mils & below)	2,403
Sheet (over 12 mils)	27
Injection molding	445
Wire & cable	*
Extrusion coating	*
Blow molding	19
Pipe & conduit	*
Other extruded products	228
All other uses (incl. Resellers & Compounders	591
Total	**3,713**

*Included in Other extruded products

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young.

[1] Data does not include Low Density Polyethylene.

[2] Data includes sales from imports.

NYLON

MANUFACTURERS*

Allied Chemical Co.
ATOCHEM Inc.
BASF Corp.
Belding Chemical Industries
Custom Resins, div. Bemis Co.
DuPont
Emser Industries
Hoechst Celanese
Mobay Corp.
Monsanto Company
Nylon Corp. of America
Shakespeare Co.
Wellman, Inc.

* Those manufacturers who participated in the SPI Monthly Statistical Report in 1989.

	CAPACITY	UTILIZATION RATE (%)
1979	410	79.8
1980	428	64.0
1981	442	70.6
1982	429	53.1
1983	431	74.5
1984	511	77.5
1985	553	72.2
1986	509	91.4
1987	548	92.5
1988	614	92.2
1989	679	83.8

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE**
1979	327	315
1980	274	271
1981	312	288
1982	228	247
1983	321	329
1984	396	389
1985	399	403
1986	465	443
1987	507	499
1988	566	574
1989	569	581
Compound Growth Rate		
1979-1989	5.7%	6.3%

** Data includes sales from imports.

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young.

NYLON

DOMESTIC CONSUMPTION BY END-USE

(thousands of pounds)

END-USE	1985	1986	1987	1988	1989**
Automotive and Truck	166,232	167,741	158,945	166,470	168,912
Electrical and Electronic[1]	42,286	46,996	58,826	61,967	62,753
Appliances	7,559	6,254	7,722	8,482	13,449
Film and Coating	41,698	46,459	52,763	66,998	70,869
Wire and Cable	21,093	22,269	27,288	26,064	30,734
Monofilament	16,006	20,753	19,924	25,930	21,330
Consumer[2]	20,930	24,604	30,381	27,563	22,223
Industrial/Machinery	31,931	26,600	30,314	35,750	43,966
Others	30,739	41,761	53,070	75,656	68,922
Total	**378,474**	**403,437**	**439,233**	**494,880**	**503,158**

[1]Includes electrical and electronic applications not assignable to automotive and truck or appliance markets

[2]Includes such items as housewares, brushes, combs, sporting goods, cameras and toys

Source: SPI Committee on Resin Statistics, as compiled by Ernst & Young

DISTRIBUTION BY MAJOR MARKET

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989**
Transportation	180	192	164	164	156
Packaging	*	*	51	77	86
Building and Construction	*	*	*	26	22
Electrical/Electronic	67	71	94	82	89
Furniture and Furnishings	5	6	10	32	24
Consumer and Institutional	*	31	36	31	40
Industrial/Machinery	32	32	32	37	37
Adhesives/Inks/Coatings	*	*	*	5	6
All Other	95	72	53	40	43
Exports	24	39	59	80	77
Total	**403**	**443**	**499**	**574**	**580**

*Included in All Other

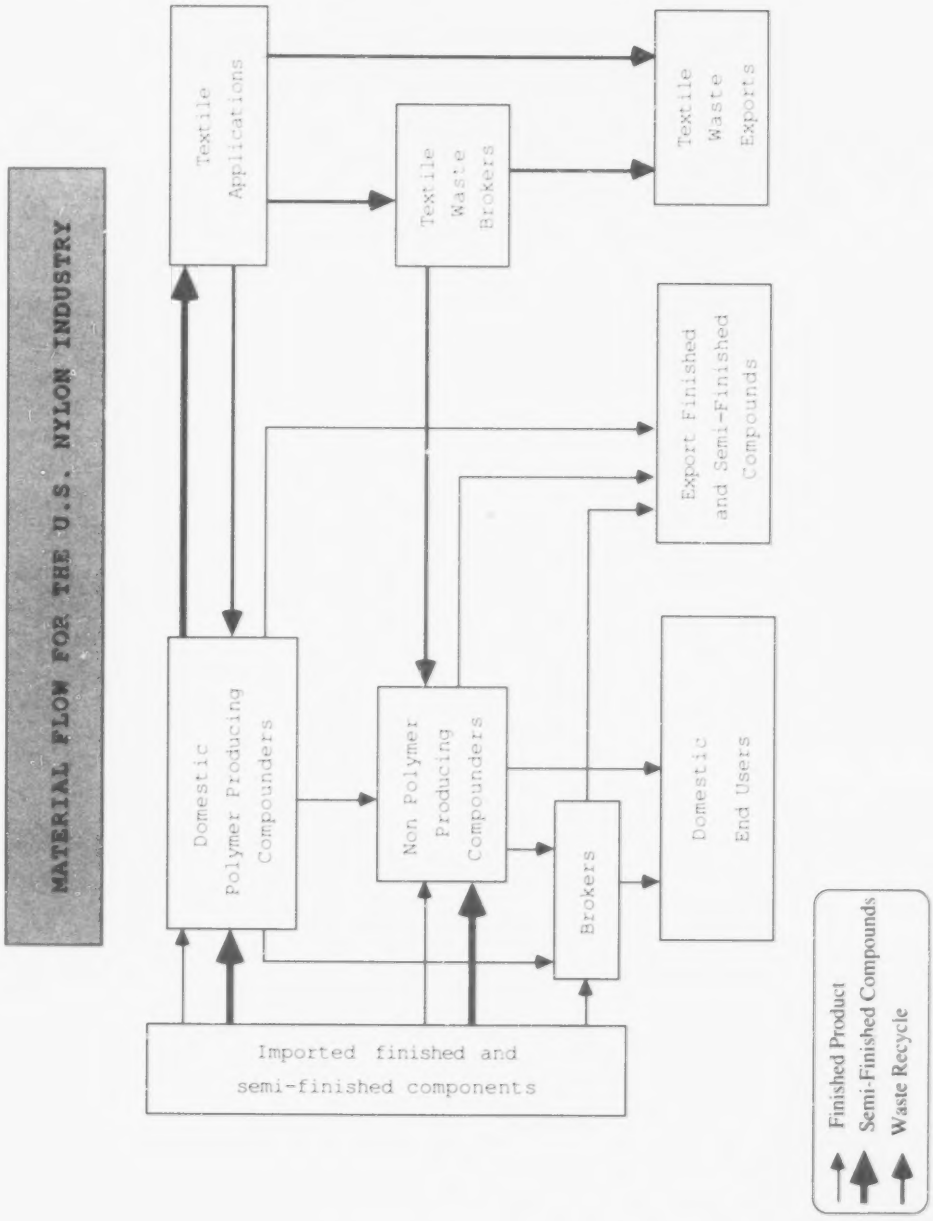
Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Electrical connectors
Fender extensions
Brush bristles
Auto components
Gears, Gearing
Wire jackets
Power tool housings
Fishing line
Food packaging
Pulleys
Emission cannisters
Cooking bags
Sutures
Lawn/Garden equipment

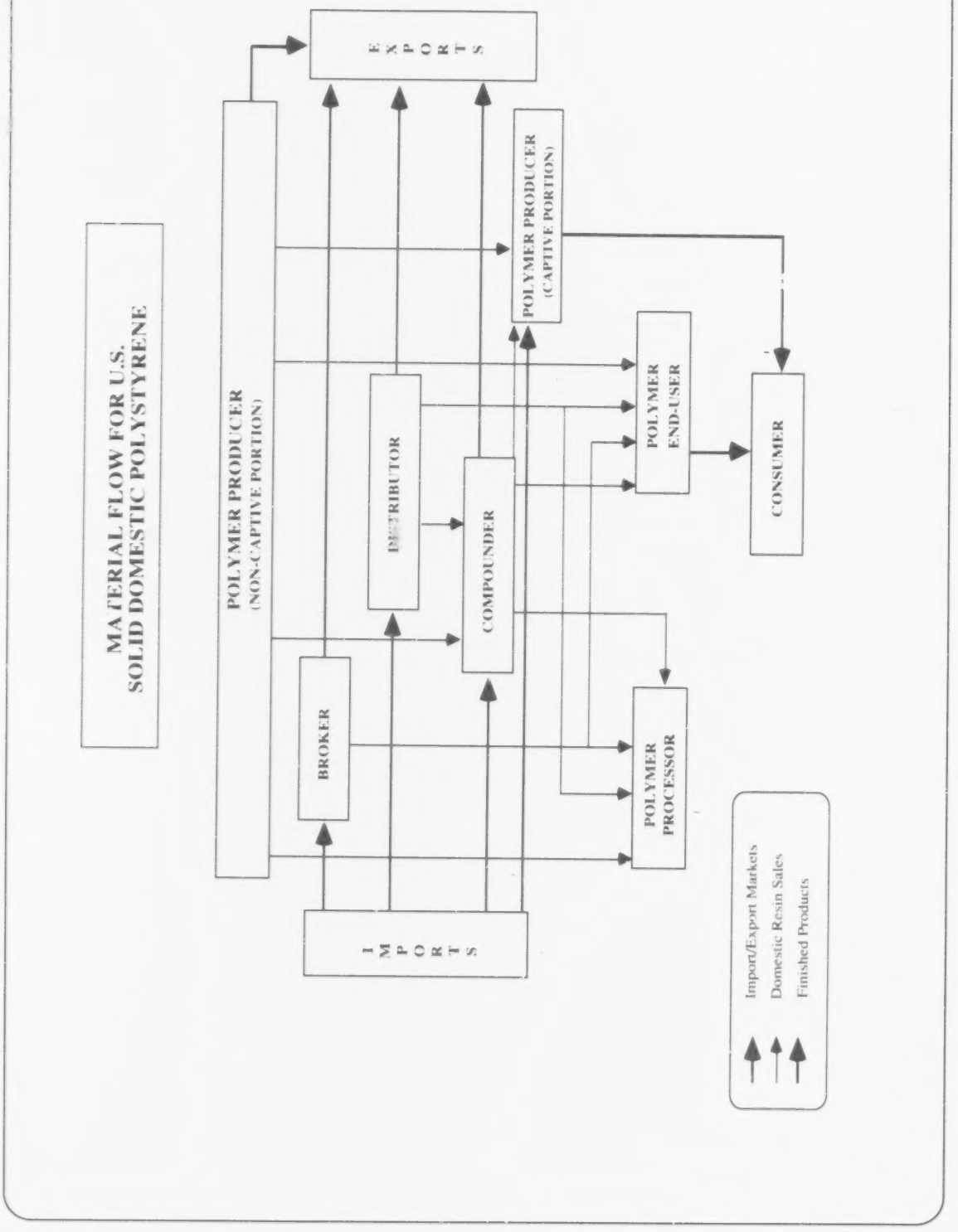
** Data includes sales from imports.

Thermoplastic Resins



Source: SPI's Committee on Resin Statistics, Nylon Subcommittee

Thermoplastic Resins



Source: SPI's Committee on Resin Statistics, Polystyrene Subcommittee

Thermoplastic Resins

POLYSTYRENE

MANUFACTURERS*

A & E Plastics
American Polymers, Inc.
Amoco Chemical Corp.
ARCO Chemical Co.
BASF Corp.
Chevron Chemical Co.
Dart Container Corp.
Dow Chemical USA
Fina Oil & Chemical
Huntsman Chemical Corp.
Mobil Chemical Co.
Nova [illegible]astics, Inc.
Scott [illegible]ymers

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1989.

	CAPACITY	UTILIZATION RATE (%)
1979	5,201	77.0
1980	5,244	67.1
1981	5,161	70.2
1982	5,176	61.7
1983	5,189	68.7
1984	5,365	71.5
1985	5,158	78.6
1986	5,182	86.3
1987	5,221	91.6
1988	5,703	91.0
1989	6,040	84.5

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1979	4,005	3,997
1980	3,521	3,518
1981	3,621	3,604
1982	3,191	3,200
1983	3,567	3,606
1984	3,838	3,836
1985	4,054	4,108
1986	4,470	4,463
1987	4,780	4,860
1988	5,187	5,027
1989	5,104	5,131
Compound Growth Rate		
1979-1989	2.4%	2.5%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young.

POLYSTYRENE

DOMESTIC CONSUMPTION BY END-USE

(millions of pounds)

END-USE	1985	1986	1987	1988	1989
Straight Polystyrene	2,078	2,260	2,526	2,690	2,759
Rubber-Modified Polystyrene	1,946	2,088	2,221	2,337	2,371
Total	**4,024**	**4,348**	**4,747**	**5,027**	**5,130**
Molding	1,403	1,540	1,857	1,849	2,007
Extrusion	1,737	1,966	2,105	2,180	2,055
Expandable Polystyrene Beads	521	497	523	586	684
All Other Uses	363	345	262	250	160
Total Domestic	**4,024**	**4,348**	**4,747**	**4,865**	**4,906**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

DISTRIBUTION BY MAJOR MARKET

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989
Transportation	*	*	*	6	*
Packaging	1,292	1,360	1,421	1,726	1,340
Building and Construction	449	418	571	506	502
Electrical/Electronic	309	360	460	611	783
Furniture and Furnishings	47	47	40	127	205
Consumer and Institutional	1,090	1,296	1,668	1,306	1,189
Industrial/Machinery	*	*	--	--	*
Adhesives/Inks/Coatings	*	*	*	--	--
All Other	837	868	587	584	887
Exports	84	114	113	161	224
Total	**4,108**	**4,463**	**4,860**	**5,027**	**5,130**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

SOME APPLICATIONS

Disposable Serviceware	Video cassettes	Business machines
Pallets	Appliance parts	Syringes
Trays	Roofing insulation	Egg cartons

Thermoplastic Resins

POLYPROPYLENE

MANUFACTURERS*

Amoco Chemical Corp.
Aristech Chemical Co.
Eastman Chemical Products, Inc.
Exxon Chemical Co.
Fina Oil & Chemical
Genesis Polymers
Himont U.S.A.
Huntsman Chemical Corp.
Phillips 66 Co.
Quantum Chemical Corp.
Rexene Corp.
Shell Chemical Company
Soltex Polymer Corp.

* Those manufacturers who participated in the SPI Monthly Statistical Report in 1989.

	CAPACITY	UTILIZATION RATE (%)
1979	5,035	76.3
1980	5,194	70.2
1981	5,056	78.2
1982	5,088	68.3
1983	5,272	84.1
1984	5,625	87.8
1985	5,800	88.6
1986	6,162	94.3
1987	6,865	96.9
1988	7,985	91.1
1989	8,865	81.6

PRODUCTION AND SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1979	3,841	3,894
1980	3,648	3,714
1981	3,955	3,888
1982	3,477	3,623
1983	4,434	4,464
1984	4,940	4,816
1985	5,139	5,275
1986	5,812	5,824
1987	6,647	6,720
1988	7,274	7,088
1989	7,238	7,303
Compound Growth Rate		
1979-1989	6.5%	6.5%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

POLYPROPYLENE

DOMESTIC CONSUMPTION BY END-USE

(millions of pounds)

END-USE	1985	1986	1987	1988	1989
Injection molding, total	1,274	1,289	1,647	1,710	1,779
Appliances	114	127	141	146	160
Consumer products	310	311	430	418	564
Rigid packaging	387	430	527	607	601
Transportation	340	308	324	313	265
All other injection molding	123	113	225	226	189
Blow molding	105	106	114	132	129
Film (10 mils & below)	389	498	559	586	584
Sheet	44	39	82	126	128
Other extruded products (including wire & cable, pipe & conduit, and extrusion coating)	89	98	126	102	95
Fiber & filaments	1,433	1,516	1,750	1,841	1,954
All other uses	1,066	1,148	1,197	1,411	1,436
Total	**4,400**	**4,694**	**5,475**	**5,908**	**6,105**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

DISTRIBUTION BY MAJOR MARKET

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989
Transportation	230	237	276	438	390
Packaging	1,000	1,128	1,450	1,632	1,447
Building and Construction	*	*	34	151	111
Electrical/Electronic	273	277	290	196	197
Furniture and Furnishings	1,119	1,103	1,255	1,218	1,313
Consumer and Institutional	621	732	966	1,102	1,306
Industrial /Machinery	11	*	*	84	--
Adhesives/Inks/Coatings	*	*	*	*	--
All Other	1,146	1,217	1,204	1,087	1,279
Exports	875	1,130	1,245	1,180	1,260
Total	**5,275**	**5,824**	**6,720**	**7,088**	**7,303**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

TYPICAL APPLICATIONS

Retort pouches
Tobacco wrap
Bottles
Appliance parts
Microwave oven containers
Fibers/Filaments
Diaper coverstock
Industrial fabrics
Pipes and profiles
Battery cases
Carpet backing
Threaded caps
Wire/Cable coating
Automotive interior trim
Filter plates
Toys
Carpet face yarn
Straws
Housewares
Syringes
Outdoor Furniture

POLYVINYL CHLORIDE

Air Products & Chemicals
CertainTeed Products Corp.
Formosa Plastics
Georgia-Gulf Corp.
B.F. Goodrich Chemical Co.
Goodyear Tire & Rubber Co.
Keysor-Century Corp.
Occidental Chemical Co.
Shintech, Inc..
Vista Chemicals.
Vygen

*Those manufacturers who participated in the SPI Monthly Statistical Report in 1989

	CAPACITY	UTILIZATION RATE (%)
1979	7,093	86.3
1980	7,126	76.8
1981	7,528	75.8
1982	7,389	72.1
1983	7,655	79.2
1984	8,317	81.3
1985	8,355	81.1
1986	8,036	90.3
1987	8,335	95.6
1988	8,906	93.8
1989	9,288	91.3

TYPICAL APPLICATIONS

Food wrap
Flooring
Siding
Pipe
Wall covering
Coatings
Upholstery
Garden hose
Shower curtains
Wire/Cable Insulation
Automotive seats
Medical Tubing
Doors
Window frames
Molding
Credit Cards
Appliance housings
Bottles
Apparel
Toys

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1979	6,119	6,138
1980	5,470	5,407
1981	5,707	5,601
1982	5,326	5,455
1983	6,066	6,152
1984	6,760	6,798
1985	6,772	6,720
1986	7,256	7,412
1987	7,971	8,081
1988	8,350	8,287
1989	8,478	8,493
Compound Growth Rate		
1979-1989	3.4%	3.3%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

POLYVINYL CHLORIDE

DOMESTIC CONSUMPTION BY END USES

(millions of pounds)

	1985	1986	1987	1988	1989
Calendering, total	**690**	**716**	**779**	**856**	**913**
Flooring	161	163	188	205	220
Textile	71	79	110	128	117
All other calendering	458	474	481	523	576
Coating, total	**303**	**330**	**377**	**370**	**361**
Flooring	125	144	165	156	153
Textile & paper coating	93	97	110	108	106
Protective coatings	46	48	52	55	51
Adhesives & all other coatings	39	41	50	51	51
Extrusion, total	**4,481**	**4,898**	**5,296**	**5,248**	**5,056**
Wire & cable	455	419	464	433	388
Film & sheet	226	258	348	378	368
Rigid pipe & tubing (except fittings)	2,809	3,165	3,352	3,217	2,990
All other extrusions	991	530	504	529	548
Siding, siding accessories & mobile homes & skirts	NA	526	628	691	762
Molding, total	**465**	**495**	**515**	**544**	**518**
Bottles	163	188	176	215	217
Sound records	68	54	NA	NA	NA
Fittings (rigid pipe & tubing)	160	141	161	165	147
All other molding	74	112	178	164	154
Paste processes (except coating), total	**156**	**156**	**167**	**168**	**174**
Plastisol formulation	77	76	88	87	94
All other	79	80	79	81	80
Resellers & Compounders	**101**	**332**	**361**	**384**	**317**
All other uses	**233**	**115**	**155**	**200**	**236**
Grand Total	**6,429**	**7,042**	**7,650**	**7,770**	**7,575**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

DISTRIBUTION BY MAJOR MARKETS

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989
Transportation	141	149	*	153	160
Packaging	572	497	614	703	582
Building and Construction	4,198	4,711	5,056	4,920	4,782
Electrical/Electronic	479	478	524	559	573
Furniture and Furnishings	310	380	292	249	284
Consumer and Institutional	230	277	265	558	657
Industrial/Machinery	30	17	*	26	*
Adhesives/Inks/Coatings	89	83	110	136	465
All Other	379	450	790	466	372
Exports	292	370	430	517	918
Total	**6,720**	**7,412**	**8,081**	**8,287**	**8,493**

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

*Included in All Other NA = Not Available

POLYVINYL ACETATE

Polyvinyl acetate is produced by the emulsion polymerization of vinyl acetate to yield a water emulsion with a solids content of 50-55%. Commercial exploitation of this polymer began in the early 1930's, although its discovery dates from the early 1900's. Early production of the resin was primarily as a homopolymer, but more recently resin properties have been changed by including comonomers such as n-butyl acrylate, 2-ethylhexyl-acrylate, ethylene, dibutylmaleate, and dibutylfumarate. Because of the large number of polyvinyl acetate producers, the numerous copolymers included and the variety of physical forms, polyvinyl acetate production is reported to SPI in terms of vinyl acetate monomer sold to or used by the polymerizer.

Polyvinyl acetate resins are primarily used in aqueous emulsions and find utility in adhesives, paints, textile finishes, and paper coating applications. A typical example of a polyvinyl acetate emulsion is the "white glue" used in many homes and schools.

There are more than 40 producers of polyvinyl acetate, supplied with monomer by such companies as DuPont, Hoechst Celanese, Quantum Chemical Corp., USI Division, and Union Carbide Corp.

SALES AND CAPTIVE USE OF VINYL ACETATE MONOMER

FOR POLYVINYL ACETATE

(thousands of pounds)

Year	Emulsion Paint	Adhesives	Paper	Textile	Non-woven Binders	Others	Export	Total
1984	203,282	275,002	119,528	25,924	30,896	28,767	6,976	690,375
1985	204,497	262,437	110,969	31,964	NA	58,185	6,124	674,176
1986	233,730	254,056	110,001	32,027	NA	56,340	3,964	690,118
1987	236,501	249,763	121,823	34,130	NA	59,961	6,596	708,774
1988	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA

COMPOUND GROWTH RATE

TOTAL SALES & CAPTIVE USE

1984-1985	-0.1%
1985-1986	2.4%
1986-1987	2.7%

NA = Not Available

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

OTHER VINYL RESINS

Vinyl resins included in this category are polyvinyl butyral, polyvinyl formal, and polyvinylidene chloride and their respective copolymers containing at least 50% of the base resin.

Polyvinyl butyral and polyvinyl formal are prepared by reacting polyvinyl alcohol with butyraldhyde or formaldehyde in the presence of a strong mineral acid. There are many grades of these products in use, differing in degree of hydroxyl substitution and molecular weight. The largest end of polyvinyl butyral is as the adhesive film in the lamination of auto safety glass. The major use of polyvinyl formal is in magnet wire coatings.

Polyvinylidene chloride is prepared by suspension or emulsion polymerization of vinylidene chloride. It finds major application as a film or as a coating on flexible substrates for packaging food products where oxygen impermeability and oil resistance are important.

Producers of these vinyl resins include Dow, DuPont, W.R. Grace, Monsanto, Morton Industries, Rohm and Haas, and Unocal Corp.

PRODUCTION AND SALES & CAPTIVE USE

(thousands of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE
1984	187,209	186,619
1985	189,699	191,437
1986	194,924	180,357
1987	212,314	203,643
1988	221,693	208,059
1989	220,398	201,052

GROWTH RATE OF SALES & CAPTIVE USE

1984-1985	2.6%
1985-1986	-5.8%
1986-1987	12.9%
1987-1988	2.2%
1988-1989	-3.4%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

THERMOPLASTIC POLYESTER

MANUFACTURERS*

Allied	Eastman Chemical Products, Inc.	Hoechst-Celanese
BASF Corp.	G.E. Plastics Co.	ICI Americas, Inc.
DuPont	Goodyear Chemical Div.	

* Those manufacturers who participated in the SPI Monthly Statistical Report in 1989.

	CAPACITY	UTILIZATION RATE (%)
1981	996	61.2
1982	1,001	64.7
1983	1,029	75.6
1984	1,038	86.6
1985	1,022	94.4
1986	1,253	93.8
1987	1,887	73.9
1988	2,270	72.8
1989	2,695	60.5

PRODUCTION, SALES & CAPTIVE USE

(millions of pounds)

YEAR	PRODUCTION	SALES & CAPTIVE USE[1]
1980	503	511
1981	610	581
1982	648	619
1983	778	783
1984	899	859
1985	965	956
1986	1,175	1,160
1987	1,394	1,411
1988	1,652	1,643
1989	1,630	1,707
Compound Growth Rate		
1980-1989	14.0%	14.3%

[1] Data includes sales from imports.

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

THERMOPLASTIC POLYESTER

(millions of pounds)

END-USE	1985	1986	1987	1988	1989[1]
PET Bottle Grades	622	722	883	942	958
All Other	220	287	343	472	463
TOTAL	**842**	**1,009**	**1,226**	**1,414**	**1,421**

Source: Monthly Statistical Report, SPI Committee on Resin Statistics, as compiled by Ernst & Young

(millions of pounds)

MAJOR MARKET	1985	1986	1987	1988	1989[1]
Transportation	63	*	*	*	*
Packaging	702	839	985	1,088	1,025
Building and Construction	*	*	*	*	*
Electrical/Electronic	*	48	*	*	*
Furniture and Furnishings	*	3	*	*	*
Consumer and Institutional	*	*	*	*	*
Industrial /Machinery	*	5	6	6	5
Adhesives/Inks/Coatings	*	*	*	*	*
All Other	10	*	57	320	392
Exports	114	*	185	229	286
Total	**956**	**1,175**	**1,411**	**1,643**	**1,708**

*Included in All Other

Source: SPI Committee on Resin Statistics Annual Major Markets Survey

Bottles	Paperboard coating	Packaging
Strapping	Monofilament	Recording tapes

[1] Data includes sales from imports.

DOMESTIC SALES & USE

SELECTED THERMOPLASTICS BY PROCESS GRADE

(millions of pounds)

MATERIAL/YEAR	TOTAL	INJECTION MOLDING	EXTRUSION	BLOW MOLDING	OTHER
Grand Total*					
1984	29,007	5,778	13,407	2,620	4,741
1985	30,407	5,849	14,918	2,948	5,292
1986	32,538	6,052	15,526	3,182	5,647
1987	33,626	NA	NA	NA	NA
1988	38,437	NA	NA	NA	NA
1989	38,659	NA	NA	NA	NA
LD Polyethylene					
1984	7,442	612	5,819	43	968
1985	7,660	583	5,894	47	1,136
1986	7,859	575	6,487	39	758
1987	8,609	697	7,110	54	748
1988	9,271	758	7,524	76	913
1989	9,681	858	7,248	79	1,496
Growth Rate					
1984-1989	5.7%	7.0%	4.5%	13.0%	9.1%
HD Polyethylene					
1984	5,253	1,191	1,133	2,079	850
1985	5,774	1,538	1,204	2,245	787
1986	6,103	1,550	1,275	2,400	878
1987	7,272	1,780	1,641	2,884	967
1988	7,435	1,658	1,767	3,002	1,008
1989	7,250	1,451	1,841	2,879	1,079
Growth Rate					
1984-1989	6.7%	4.0%	10.1%	6.7%	4.8%
Polypropylene					
1984	4,034	1,290	1,903	105	736
1985	4,400	1,274	1,955	105	1,066
1986	4,694	1,289	2,152	106	1,147
1987	5,475	1,647	2,517	114	1,197
1988	5,908	1,710	2,654	132	1,412
1989	6,105	1,779	2,761	129	1,436
Growth Rate					
1984-1989	8.6%	6.7%	7.7%	4.2%	14.3%
ABS[a]					
1984	1,000	600	150	---	250
1985	900	575	125	---	200
1986	1,080	NA	NA	---	NA
1987	1,208	NA	NA	---	NA
1988	1,279	NA	NA	---	NA
1989	1,217	NA	NA	---	NA
Growth Rate					
1984-1989	4.0%	NA	NA	---	NA

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as compiled by Ernst & Young

* = Not comparable, reporting changes in 1986 NA = Not Available [a] ABS estimated 1984-1985

DOMESTIC SALES & USE

SELECTED THERMOPLASTICS BY PROCESS GRADE (Cont'd)

(millions of pounds)

MATERIAL/YEAR	TOTAL	INJECTION MOLDING	EXTRUSION	BLOW MOLDING	OTHER
Polystyrene					
1984	3,735	1,436	1,468	---------	831
1985	4,024	1,403	1,737	---------	884
1986	4,348	1,540	1,966	---------	842
1987	4,747	1,857	2,105	---------	785
1988	4,865	1,849	2,180	---------	836
1989	4,906	2,007	2,055	---------	844
Growth Rate					
1984-1989	5.5%	7.0%	7.0%	---------	0.4%
Nylon					
1984	363	243	95	---------	25
1985	378	251	100	---------	27
1986	403	266	112	---------	25
1987	439	267	131	---------	41
1988	495	293	148	---------	54
1989	503	303	148	---------	52
Growth Rate					
1984-1989	6.8%	4.5%	9.3%	---------	16.9%
Thermoplastic Polyester[b]					
1984	760	200	20	535	5
1985	842	190	25	622	5
1986	1,009	NA	NA	NA	NA
1987	1,226	NA	NA	NA	NA
1988	1,414	NA	NA	NA	NA
1989	1,422	NA	NA	NA	NA
Growth Rate					
1984-1989	13.4%	NA	NA	NA	NA
P V C					
1984	6,420	277	4,330	186	1,627
1985	6,429	228	4,481	163	1,557
1986	7,042	306	4,899	188	1,649
1987	7,650	339	5,296	176	1,839
1988	7,770	329	5,248	215	1,978
1989	7,575	301	5,056	217	2,001
Growth Rate					
1984-1989	3.3%	1.8%	3.2%	3.2%	4.2%

Source: Monthly Statistical Report, SPI Committee on Resin Statistics as compiled by Ernst & Young

NA = Not Available. [b]Thermoplastic Polyester estimated 1984-1985.

The Society of the Plastics Industry, Inc.

Recycling

THE COUNCIL FOR SOLID WASTE SOLUTIONS

Founded in 1988, The Council for Solid Waste Solutions is a task force of companies in the plastics industry developing comprehensive, realistic programs for the environmentally sound disposal and recycling of plastics.

The Council's Technical Department is helping get new waste management technologies from the design table to the production line. Meanwhile, the Council's Government Affairs and Communications Departments are working with local, state and federal officials as well as community and environmental organizations, to put these solutions in place.

Technical Programs

A central feature of the Council's technical program for 1990 is the Blueprint for Plastics Recycling -- a comprehensive, centrallized market plan to guide the growing plastics recycling industry. An extensive municipalities program supports the Blueprint, providing equipment and guidance to communities seeking to recycle plastics.

In addition, the technical department is continuing its direction and sponsorship of university and field research activities on a variety of plastics recycling and disposal issues.

Government Affairs Programs

The Council is helping to shape legislation at the federal, state and local government levels, offering alternatives to restrictive legislation and sponsoring symposia bringing new technologies and information to legislative audiences.

Communications Programs

The Council's communications programs are designed to correct misconceptions about plastics in the waste stream and promote technical research developments. In 1990, the Council is communicating its message to an ever-broader segment of the American public through a national print advertising campaign, a store-based consumer education program, and a national schools program targeting junior and senior high students and educators.

The Council for Solid Waste Solutions
1275 K Street, N.W.
Suite 400
Washington, D.C. 20005

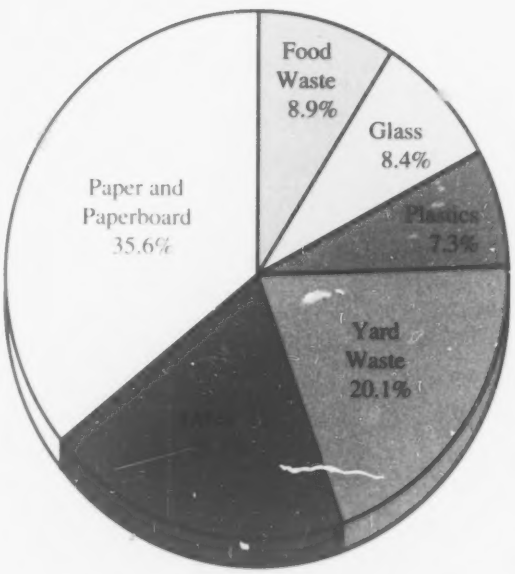
Municipal Solid Waste

Many communities throughout the U.S. are struggling with the question of how to safely and effectively manage municipal solid waste. Most are discovering that there are no quick-fix solutions to the waste management problem, and that the only real solution is an integrated waste management approach that utilizes four basic mathods:

1. Source Reduction
2. Recycling
3. Waste-to-Energy Incineration
4. Landfilling

An integrated system matches these four waste management methods to the material components of the solid waste stream, assuring that the methods best suited to specific waste stream materials are utilized. This integrated approach allows a community to design a waste management program that reflects the community's population and waste stream characteristics, and the best possible mix of waste management solutions tailored to the local economy.

Municipal Waste Stream Composition*

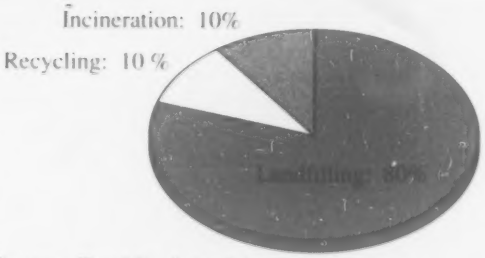


* Wastes discarded after materials recovery and before energy recovery on the basis of weight, 1986.

Source: Franklin Associates, Ltd.

Plastics Recycling

As community and state officials grapple with our nation's solid waste management dilemma, they are increasingly turning to recycling as a part of the solution. Currently, recycling plays a small but growing role in solid waste management.



Source: Franklin Associates.

Recycling

An adequate supply of plastics in the marketplace is a relatively new phenomenon and the technologies for recycling plastics in large amounts are still under development. Aluminum and glass beverage containers, as well as many types of paper -- all materials that have been in use for decades or centuries -- are currently being recycled at rates higher than plastics.

Already, 20% of all soft drink containers made from polyethylene terephthalate (PET) are being recycled; about 2% of all milk, juice and water containers made from high-density polyethylene (HDPE) are now recycled. Technologies for reclaiming and recycling other plastic materials, including polystyrene foam, vinyl, polyethylene films and mixed plastics are now under development.

While the overall recycling rate for municipal solid waste stands at about 10%, The Council for Solid Waste Solutions endorses -- and is working toward -- the U.S. Environmental Protection Agency's goal of recycling 25% of the total solid waste stream.

Plastics Codes

Plastics recyclers are finding it easier to sort containers, thanks to the plastics industry's new voluntary coding system. The system, developed by The Society of the Plastics Industry, Inc., helps recyclers to identify the types of plastic used in making individual bottles and other containers.

The codes are easy to read and easy to distinguish from other marks placed on plastic containers by manufacturers for use in processing and identification.

The code on each container consists of a triangle formed by three arrows, with a number in the center and distinguishing letters under the triangle. In size, the codes range from approximately 1/2 to 1 inch in diameter. They can be applied by molding or imprinting the bottom of the container.

Plastics Coding System

1: PETE (polyethylene terephthalate)
2: HDPE (high density polyethylene)
3: V (vinyl)
4: LDPE (low density polyethylene)
5: PP (polypropylene)
6: PS (polystyrene)
7: Other

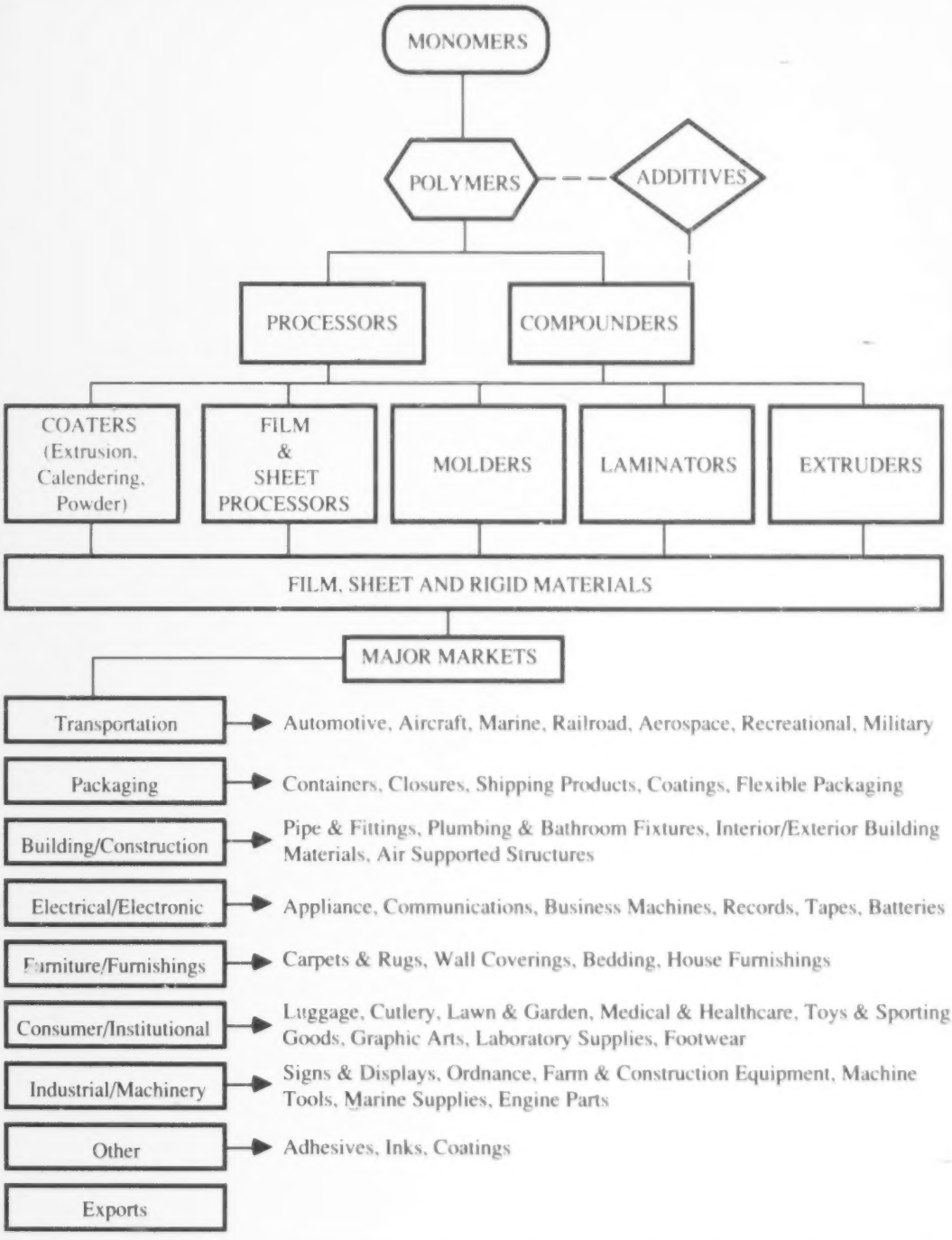
The Society of the Plastics Industry, Inc.

Fabricated Plastic Products

Fabricated Plastic Products

FLOW CHART:

FROM RAW MATERIAL TO FINISHED PRODUCT



Source: SPI Committee on Resin Statistics

Fabricated Plastic Products

COMPOSITES

Composites (also known as reinforced plastics) consist of a reinforcing fiber and a plastic resin. Reinforcing fibers include materials such as glass fiber (the most common), aramid, carbon, graphite and boron. The major plastic resin systems used are unsaturated polyester (the most common), epoxies, silicons, vinyl esters and various thermoplastic resins. Other components include fillers and a variety of additives which are also frequently added in the manufacturing process.

The fundamental characteristics of composites include lightweight, high strength-to-weight ratio, nonconductivity, corrosion-resistance and dimensional stability. In addition, composites provide considerable flexibility in design and the ability to consolidate parts. These benefits allow manufacturers to select the right combination for specific applications in every major market segment.

The composites industry enjoys a high level of technical activity due to the engineered nature of its end uses, and the relatively high value-added nature of the finished product. The search for new applications is vigorous, while new levels of performance in existing uses are continually being upgraded.

New resins and fabrication techniques are accelerating the acceptance and growth of composites. The development of new grades of engineered reinforced thermoplastics (RTP's), is also contributing to the growth of the composits industry. Over the past few years, new thermoplastic resin systems with superior resistance to high temperatures and improved surface characteristics have made possible the introduction of new product forms such as long fiber compounds, moldable or stampable sheets, pultrusion profiles, and filament winding.

In the past few years, the need for lightweight structural materials that meet strength, stiffness, and other mechanical property requirements for high performance applications, have prompted major developments in the aircraft/aerospace, construction, consumer, electrical, land transportation and marine markets. A few examples are:

Aircraft/Aerospace: The structure and interiors of both military and commercial planes are using increasing amounts of composites materials. Their light weight, moldability and versatile nature have prompted continued research and development in this industry resulting in growing replacement of the traditional metal parts by composites.

Consumer: The sports equipment market has led the way in the hybridization of carbon and glass to get the proper stiffness and weight in skis, ski poles, tennis racquets, fishing rods and golf club shafts.

Land Transportation: Composites are being used in automobiles, mobile homes, buses, and trucks. Applications can be found in body panels, front ends, bumpers and the interior dashboards. The light weight, moldability and corrosion-resistant features of composites add to the durability of the vehicle.

Marine: In the marine market, carbon/glass hybrids have allowed hull redesign from a solid laminate to a core/skin construction for lighter weight. Carbon provides the stiffness while glass provides the necessary strength.

COMPOSITES SHIPMENTS BY MARKET

(thermoset & thermoplastic resins)
(millions of pounds)*

MARKETS	1985	1986	1987	1988[1]	1989[1]	1990[2]
Aircraft/Aerospace/Military	32	37	36	39	41	42
Appliances/Business Equipment	133	137	141	150	152	155
Construction	445	456	506	495	479	482
Consumer Products	142	149	167	169	162	164
Corrosion-Resistant Equipment	295	291	329	349	349	354
Electrical/Electronic	191	201	214	230	231	236
Marine	335	340	413	452	412	414
Land Transportation	563	585	656	695	685	702
Miscellaneous	82	83	75	80	78	80
Total	**2,218**	**2,279**	**2,537**	**2,659**	**2,589**	**2,629**

* Includes reinforcements & fillers [1]Revision [2]Forecast

Source: SPI Composites Institute

VINYL SIDING & SOFFIT

Vinyl Siding is used mainly in the construction of exterior building walls, both for new construction and retrofit. Rigid polyvinyl chloride (PVC) homopolymer is compounded (blended) with a variety of auxiliary materials such as plasticizers, stabilizers, lubricants, pigments, etc., prior to being extruded into a wall siding product. The soffit, or underside of any structural component such as the eaves, is usually made of similar PVC material.

The Vinyl Siding Institute, a division of the SPI, sponsors a statistical program with its member companies as participants. Data is collected covering U.S. shipments of vinyl siding and soffit reported in "number of squares", which are units of measure common in the building and construction industry. One square equals 100 square feet of siding or enough to cover an area ten feet by ten feet.

PARTICIPATING PRODUCERS 1989

Alcan Building Products
Alcoa Building Products/HC Products
ALSCO
Alside, Inc.
Bird, Inc.
BPCO
CertainTeed Corp.
Crane Plastics Co. (VIPCO)
Daymond
Duchesne et Fils, Ltee.
Elixer Industries
Gold Bond Building Products
Heartland Building Products (Div. of Daymond)
Master Shield, Inc.
Mastic Corporation
Sauder Industries, Ltd.
SEVCO (Reynolds Metals)
Variform
Vytec Corp.
Wolverine Technologies, Inc.

U.S. SHIPMENTS OF VINYL SIDING & SOFFIT

	Number of Squares*	Percent Change
1986	12,397,916	
1987	15,615,091	+ 26.0
1988	16,511,279	+ 5.7
1989	17,600,093	+ 6.6

Source: SPI Vinyl Siding Institute

* Believed to represent more than ninety percent of total U.S. Shipments.

VINYL WINDOWS

Vinyl Windows are fabricated from lineals of polyvinyl chloride (PVC). The lineals make up the framing and structural parts of windows, patio doors, skylights and similar fenestration products, which are then glazed with conventional glazing materials. A window is considered to be "vinyl" if made from 50% or more PVC material. Many different types of vinyl windows -- for example, double and single hung windows, horizontal sliders, casements, picture windows and specialized windows such as half rounds and hexagons -- are used in remodeling and new construction for both residential and commercial structures.

The Vinyl Window and Door Institute, a division of the SPI, sponsors a statistical program which collects data on U.S. shipments of vinyl windows. The data are reported by producers of vinyl window extrusions, based on a formula reflecting shipments by window fabricators.

PARTICIPATING PRODUCERS 1989

ACRO Extrusion Corp.
Bird, Inc.
CertainTeed Corp.
Chelsea Building Products
Custom Window Extrusions
Dayton Extruded Plastics, Inc.
EASCO Aluminum Corp.
Fiberlux, Inc.
Great Lakes Window Corp.
Kessler Products
Komcraft
L.B. Plastics, Inc.
Master Shield
Mikron Industries, Inc.
Plains Plastics
Spectus Systems
Thermal Industries
United Thermal Plastics
Vekaplast
VICOA Corp.
Vinyl Building Products, Inc.
Vinylume Products
Wolverine Technologies, Inc.

U.S. SHIPMENTS OF VINYL WINDOWS

	Number of Units	Percent Change
1988	5,863,418	
1989	6,233,321	+ 6.3

Source: SPI Vinyl Window and Door Institute

PLASTIC BOTTLES

SHIPMENTS

(in millions of units)

BY MARKET	1986[R]	1987[R]	1988[R]	1989[1]
Household Chemicals	3,466	4,136	4,501	4,712
Industrial Chemical	433	400	428	478
Automotive & Marine	2,455	2,700	2,903	3,047
Toiletries & Cosmetics	2,530	2,889	2,975	3,210
Medicinal & Health	3,522	4,113	4,154	4,379
Food				
Milk	5,079	5,291	5,317	5,462
Other food	1,622	2,540	2,514	2,587
Beverages				
Carbonated Soft Drinks	6,600	7,000	7,150	7,050
Other beverages	2,399	2,640	2,798	2,961
Other	1,411	1,425	1,439	1,455
Total	**29,517**	**33,134**	**34,179**	**35,341**

EXPLANATION OF TERMS

Household Chemicals - Bleach, dishwashing, laundry, and other detergents; fabric softeners; bowl and drain cleaners; dry cleansers; floor care products; soaps (including medicated); window cleaners; air fresheners; household pesticides and garden chemicals; household adhesives; waxes and polishes (including car polish); car wax, wax and polish remover, etc.

Industrial, Agricultural and Specialty Chemicals - Agricultural, industrial, and institutional chemical and cleaning products; photographic chemicals; battery acid; paint and varnish supplies, etc.

Toiletries and Cosmetics - shampoos and other hair grooming products; talcs and powders; hand, face, and body lotions and ointments; shaving preparations; bath products; perfumes, toilet water, and colognes; personal deodorant, etc.

Medicinal and Health - Oral antiseptics and mouthwashes; laxatives; pharmaceutical lotions, creams, and ointments; pain relievers; vitamins; rubbing alcohols; antacids, etc.

Food and Beverages - Milk, carbonated beverages; noncarbonated beverages such as juices, water, cider, etc.; distilled spirits and other alcoholic beverages; edible oil; and all other food items.

Automotive and Marine - Antifreeze; motor oil; lubricants; defrosters; windshield cleaners; hydraulic fluids; additives, etc.

CONSUMPTION OF MATERIALS

(in millions of pounds)

BY MARKET	1986	1987	1988[R]	1989[1]
LD Polyethylene	54	47	70	66
HD Polyethylene	2,365	2,587	2,703	2,851
Polyvinyl Chloride	204	214	212	220
Polypropylene	113	119	129	135
Polyethylene Terephthalate	754	881	930	990
Polystyrene & Other	51	53	48	53
Total	**3,541**	**3,901**	**4,092**	**4,315**

[1] = Estimate [R] = Revised

Source: U.S. Department of Commerce; Census & ITA

The Society of the Plastics Industry, Inc.

Processing and Machinery

PROCESSING METHODS

INJECTION MOLDING

Injection molding is the principal method of forming thermoplastic materials. Modifications of the injection process are sometimes used for thermosetting plastics.

In injection molding, plastic material is put into a hopper which feeds into a heating chamber. A plunger pushes the plastic through this long heating chamber where the material is softened to a fluid state. At the end of this chamber there is a nozzle which abuts firmly against an opening into a cool, closed mold. The fluid plastic is forced at high pressure through this nozzle into the cold mold. As soon as the plastic cools to a solid state, the mold opens and the finished plastic is ejected from the press.

The problem with injection molding of thermosetting materials is that, under heat, these plastics will first soften, then harden to an infusible state. Thus it is essential that no softened thermosetting material in the heating chamber be allowed to remain there long enough to set. Jet molding, offset molding and molding using a screw-type machine overcome this problem by liquefying the thermosetting plastic material just as it goes through the injection nozzle into the mold, but not before.

BLOW MOLDING

Blow molding is a method of forming used with thermoplastic materials.

Basically, blow molding consists of stretching and then hardening a plastic against a mold. There are two general methods of doing this type of thermoplastic molding: the direct method and the indirect method, encompassing several variations of each.

In the direct method, a glob of molten thermoplastic material is formed into the rough shape of the desired finished product. This shape is then inserted in a female mold and air blown into the plastic, as into a balloon, to force it against the sides of the mold. The formed material is then cooled before removal from the mold.

In the indirect method, a thermoplastic sheet or special shape is first heated, then clamped between a die and cover. Air pressure forced between the plastic and the cover forces the material into contact with the die, which has the contour desired in the finished product. The plastic is cooled before removal from contact with the die.

THERMOFORMING

Thermoforming of plastic sheet has developed rapidly in recent years. Basically, this process consists of heating thermoplastic sheet to a formable plastic state and then applying air and/or mechanical assists to shape it to the contours of a mold.

Air pressure may range from almost zero to several hundred psi *. Up to approximately 14 psi (atmospheric pressure), the pressure is obtained by evacuating the space between the sheet and the mold in order to utilize this atmospheric pressure. This range, known as *vacuum forming*, will give satisfactory reproduction of the mold configuration in the majority of forming applications.

* psi= pounds per square inch.

TRANSFER MOLDING

Transfer molding is most generally used for thermosetting plastics.

This method is like compression molding in that the plastic is cured into an infusible state in a mold under heat and pressure. It differs from compression molding in that the plastic is heated to a point of plasticity before it reaches the mold and is forced into a closed mold by means of an hydraulically-operated plunger.

Transfer molding was developed to facilitate the molding of intricate products with small deep holes or numerous metal inserts. The dry mold compound used in compression molding sometimes disturbs the position of the metal inserts and the pins which form the holes. The liquified plastic material in transfer molding flows around these metal parts without causing them to shift position.

REACTION INJECTION MOLDING

Reaction injection molding (RIM) is a relatively new processing technique that has rapidly taken its place alongside more traditional methods. Unlike liquid casting, the two liquid components, polyols and isocyanates, are mixed in a chamber at relatively low temperatures (75° - 140°) before injection into a closed mold. An exothermic reaction occurs and consequently RIM requires far less energy usage than any other injection molding system.

The three major types of polyurethane RIM systems are rigid structural foam, low-modulus elastomers, and high-modulus elastomers.

Reinforced RIM (R-RIM) consists in the addition of such materials as chopped or milled glass fiber to the polyurethane to enhance stiffness and to increase modulus thus expanding the range of applications.

COMPRESSION MOLDING

Compression molding is the most common method of forming thermosetting materials. It is not generally used for thermoplastics.

Compression molding is simply the squeezing of a material into a desired shape by application of heat and pressure to the material in a mold.

Plastic molding powder, mixed with such materials or fillers as woodflour and cellulose to strengthen or give other added qualities to the finished product, is put directly into the open mold cavity. The mold is then closed, pressing down on the plastic and causing it to flow throughout the mold. It is while the heated mold is closed that the thermosetting material undergoes a chemical change which permanently hardens it into the shape of the mold. The three compression molding factors -- pressure, temperature and time the mold is closed -- vary with the design of the finished article and the material being molded.

EXTRUSION

Extrusion molding is the method employed to form thermoplastic materials into continuous sheeting, film, tubes, rods, profile shapes, filaments, and to coat wire, cable and cord.

In extrusion, dry plastic material is first loaded into a hopper, then fed into a long heating chamber through which it is moved by the action of a continuously revolving screw. At the end of the heating chamber the molten plastic is forced out through a small opening or die with the shape desired in the finished product. As the plastic extrusion comes from the die, it is fed onto a conveyor belt where it is cooled, most frequently by blowers or by immersion in water.

In the case of wire and cable coating, the thermoplastic is extruded around a continuing length of wire or cable which, like the plastic, passes through the extruder die. The coated wire is wound on drums after cooling.

In producing wide film or sheeting, the plastic is extruded in the form of a tube. This tube may be split as it comes from the die and then stretched and thinned to the dimensions desired in the finished film.

In a different process, the extruded tubing is inflated as it comes from the die, the degree of inflation of the tubing regulating the thickness of the final film.

SHIPMENTS

INJECTION MOLDING MACHINERY

(number of units)

CLAMP FORCE (Tons)	1985	1986	1987	1988	1989
0-199	543	339	372	355	392
200-299	447	309	326	392	481
300-399	371	295	293	349	372
400-499	423	329	350	388	316
500-599	109	66	95	120	224
600-749	181	126	140	171	184
750-1199	147	131	91	132	109
1200-1999	71	59	54	78	66
2000 and over	40	55	27	31	53
Grand Total	**2,332**	**1,709**	**1,748**	**2,016**	**2,197**

SINGLE SCREW EXTRUSION MACHINERY

(number of units)

SCREW DIAMETER	1985	1986	1987	1988	1989
Up to But Not Including ..... 2"	156	172	154	149	184
2" Up to But Not Including ..... 2 1/2"	115	114	117	145	168
2 1/2" Up to But Not Including ..... 3"	235	212	223	259	267
3" Up to But Not Including ..... 4"	216	213	253	258	198
4" Up to But Not Including ..... 5 1/2"	140	134	159	172	181
5 1/2" Up to But Not Including ..... 7 1/2"	76	75	62	83	106
Includes 7 1/2" & Larger	16	5	14	20	12
Total	**954**	**925**	**982**	**1,086**	**1,116**

Note: Includes domestic shipments and exports
Source: SPI Machinery Division

DOLLAR SALES *

PLASTICS MACHINERY

(millions of dollars)

MACHINE TYPE	1985	1986	1987	1988	1989
Injection Molding	376.0	315.0	257.1	292.5	343.7
Structural Foam	4.5	3.9	3.9	4.2	4.4
Extrusion, single screw	84.5	121.0	112.5	125.5	120.5
Extrusion multi screw	16.0	14.5	15.6	14.0	16.0
Blow Molding	65.0	80.0	70.0	120.0	123.0
Thermoforming	50.0	55.0	60.0	75.0	91.0
Reaction-Injection Molding	7.5	6.0	6.8	7.5	14.0
Compression	13.0	13.5	16.2	18.0	18.5
Expanded Bead	1.0	0.5	0.5	1.0	2.5
Transfer Molding	4.5	5.0	7.1	7.0	7.0
Total	**622.0**	**614.4**	**549.7**	**664.7**	**740.6**

* Includes exports; does not include imports

Source: Modern Plastics Magazine

Glossary

ADDITIVES FOR PLASTICS

ADDITIVE LUBRICANTS

These materials are added to plastics to assist flow in calendering, molding and extrusion by lubricating the metal surfaces in contact with the plastic. They also assist in knitting and wetting of the resin in mixing and milling operations. To be effective, lubricants must be compatible with the resins in which they are used, must not adversely affect the properties of end-products, and must be easily combined.

Examples: stearic acid, waxes, fatty acid esters, fatty acid amines.

ANTIOXIDANTS

They inhibit the oxidation of materials exposed to air or oxygen at normal or elevated temperatures. They are used in plastics which are subject to oxidative degradation, such as polyolefins, ABS, polystyrene, acetal and polyphenylene oxide.

Examples: alkylated phenols, amines, organic phosphites and phosphates, esters.

ANTISTATS

Chemicals which impart a slight to moderate degree of electrical conductivity to plastics compounds, thus preventing the accumulation of electrostatic charges on finished articles. They may be incorporated in the material before molding, or applied to their surfaces after molding. They function either by being inherently conductive or by absorbing moisture from the air.

Examples: quaternary ammonium compounds, anionics, amines.

BLOWING AGENTS (FOAMING AGENTS)

Substances which alone or in combination with other substances are capable of producing a cellular structure in a plastic or rubber mass. Thus, the term includes compressed gases which expand when pressure is released, soluble solids that leave pores when leached out, liquids that develop cells when they change to gases, and chemical agents that decompose or react under the influence of heat to form a gas.

Examples: azodicarbonamide, modified azos, OBSH, HTBA.

COLORANTS

Dyes or pigments which impart color to plastics. The dyes are synthetic or natural compounds of submicroscopic or molecular size, soluble in most common solvents, yielding perfectly transparent colors. The pigments are organic and inorganic substances with larger particle sizes and usually insoluble in the common solvents. Colorants are added to plastics by dry coloring (tumbling the colorant with the base or compounded resin); by extrusion coloring (extruding a dry colored mixture and chopping it into pellets to be reprocessed); by masterbatching; or by stirring colorants or dispersions thereof into liquid plastisols or resin systems.

Examples: titanium dioxide, iron oxides, anthraquinones, carbon black.

Glossary

FLAME RETARDANTS

Materials that reduce the tendency of plastic articles to burn. They are usually incorporated as additives during compounding, but sometimes are applied to surfaces of finished articles.

Examples: antimony trioxide, chlorinated paraffins, bromophenols.

HEAT STABILIZERS

Agents used in compounding some plastics to assist in maintaining the physical and chemical properties of the compounded materials at suitable values throughout the processing and service life of the material and/or the parts made therefrom. They protect plastics from the effects of heat such as changes in color decrease in mechanical and electrical properties, and undesirable surface conditions.

Examples: lead, barium-cadmium, tin, calcium-zinc.

ORGANIC PEROXIDES

Thermally decomposable compounds which can initiate polymerization reactions and effect cross-linking upon decomposition. The rate of decomposition can be controlled by means of promoters or accelerators added to the system to increase the decomposition rate; or by inhibitors when it is desired to retard the decomposition.

Examples: MEK peroxide, benzoyl peroxide, alkyl peroxide, peresters.

PLASTICIZERS

Materials incorporated in a plastic or elastomer to increase its flexibility, workability or distensibility. Most plasticizers are nonvolatile organic liquids or low-melting point solids, which function by reducing the normal intermolecular forces in a resin thus permitting the macromolecules to slide over one another more freely.

Examples: adipates, azelates, trimellitates, DOP/DIOP/DIDP.

ULTRAVIOLET STABILIZERS (UV LIGHT ARSORBERS)

Chemical agents which absorb or screen out radiation beyond the violet end of the spectrum of visible radiations. Such radiation has sufficient energy to initiate reactions leading to the degradation of many plastics. These agents are often combined with other additives, e.g. heat stabilizers and antioxidants, with which they act in synergistic fashion.

Examples: benzophenones, benzotriazole, salicylates.

Source: Whittington's Dictionary of Plastics

DEFINITIONS OF RESINS

ACETAL

An engineering thermoplastic produced by the polymerization of purified formaldehyde [CH_2O] into both homopolymer and copolymer types. Typical applications are found in consumer products, automotive parts, and industrial machinery parts.

ACRYLICS

A family of thermoplastic resins of acrylic esters [$CH_2CHCOOR$] or methacrylic esters [$CH_2C(CH_3)COOR$]. The acrylates may be methyl, ethyl, butyl, or 2-ethylhexyl. Usual methacrylates are the methyl, ethyl, butyl, laural and stearyl. Typical applications are found in lighting fixtures, glazing and automotive parts.

ACRYLONITRILE BUTADIENE STYRENE

A class of thermoplastic terpolymers including a range of resins, all prepared with usually more than 50% styrene [$C_6H_5CHCH_2$] and varying amounts of acrylonitrile [CH_2CHCN] and butadiene [$CH_2CHCHCH_2$]. The three components are combined by a variety of methods involving polymerization, graft copolymerization, physical mixtures and combinations thereof. Typical applications are found in appliances, automotive parts, pipe, business machine and telephone components.

ALKYDS

Thermosetting unsaturated polyester resins produced by reacting an organic alcohol with an organic acid, dissolved in and reacted with unsaturated monomers such as styrene [$C_6H_5CHCH_2$], diallyl phthalate [$C_6H_4(COOCH_2CHCH_2)_2$], diacetone acrylamide [$CH_3COCH_2C(CH_3)_2CHCHCONH_2$] or vinyl toluene [$CH_2CHC_6H_4CH_3$]. Typical applications are found in electrical uses, automotive parts, and as coatings.

CELLULOSICS

A family of thermoplastic resins manufactured by chemical modification of cellulose [$(C_6H_{10}O_5)_n$]. Included are: *cellophane*--regenerated cellulose made by mixing cellulose xanthate [ROCSSH] with a dilute sodium hydroxide [NaOH] solution to form a viscose, then extruding the viscose into an acid bath for regeneration; *cellulose acetate*--an acetic acid ester [$CH_3COOC_2H_3$] of cellulose; *cellulose acetate butyrate*--a mixed ester produced by treating fibrous cellulose with butyric acid [$CH_3CH_2CH_2COOH$], butyric anhydride [$(CH_3CH_2CH_2CO)_2O$], acetic acid [CH_3COOH] and acetic anhydride [$(CH_3CO)_2O$] in the presence of sulfuric acid [H_2SO_4]; *cellulose propionate*-- formed by treating fibrous cellulose with propionic acid [$CH_3CH_2CO_2H$] and acetic acid and anhydrides in the presence of sulfuric acid; *cellulose nitrate*--made by treating fibrous cellulosic materials with a mixture of nitric [HNO_3] and sulfuric acids. Typical applications are found in packaging, consumer products, and automotive parts.

COUMARONE-INDENE

Thermoplastic resin obtained by heating mixtures of coumarone [C_8H_6O] and indene [$C_6H_3CH_2CHCH$] with sulfuric acid [H_2SO_4] to promote polymerization. These resins have no commercial applications when used alone. They are used primarily as processing aids, extenders and plasticizers with other resins in asphalt floor tile.

Glossary

DIALLYL PHTHALATE(DAP)

The term DAP is used both for the monomeric and polymeric forms. The monomer [$C_6H_4(COOCH_2CHCH_2)_2$] is used as a cross-linking agent in unsaturated polyester resins. As a polymer, it is used in the production of thermosetting molding powders, casting resins and laminates.

EPOXY

Thermosetting resins, that, in the uncured form, contain one or more reactive epoxide or oxirane groups.

These epoxide groups serve as cross-linking points in the subsequent curing step, in which the uncured epoxy is reacted with a curing agent or hardener. Cross-linking is accomplished through the epoxide groups as well as through hydroxyl groups that may be present. Most conventional unmodified expoxy resins are produced from epichlorohydrin (chloropropylene oxide) [CH_2OCHCH_2Cl] and bisphenol A[$(CH_3)_2C(C_6H_4OH)_2$]. The other types of epoxy resins are phenoxy resins, novolac resins, and cycloaliphatic resins. Epoxy resins are used as protective coatings, bonding adhesives, in building and construction, and electrical uses, plus many other uses.

FLUOROPOLYMERS

A family of thermoplastic resins analogous to polyethylene in which some of the hydrogen atoms attached to the carbon chain are replaced by fluorine or fluorinated alkyl groups. In some cases, other halogens such as chlorine are also part of the molecule. The most common commercial fluoropolymers are: *FEP* (fluorinated ethylene-propylene) from tetrafluoroethylene [C_2F_4] and hexafluoropropylene [C_3F_6]; *PTFE* (polytetrafluoroethylene) from the polymerization of tetrafluoroethylene and ethylene [C_2H_4]; *PFA* (perfluoro-alkoxy) from tetrafluoroethylene and perfluoropropyl vinyl ether [$C_5H_2C_4OF_3$]; *PCTFE* (polychlorotrifluoro-ethylene) from chlorotrifluoro-ethylene monomer [C_2F_3Cl]; *CTFE-VDF* (polychlorotrifluoroethylenevinylidene fluoride) from chlorotrifluoroethylene and vinylidene fluoride [$C_2H_2F_2$]; *E-CTFE* (polyethylene-chlorotrifluoroethylene) from chlorotrifluoroethylene and ethylene; *PVDF* (polyvinylidene fluoride) from vinylidene fluoride monomer; and, *PVF* (polyvinyl fluoride) from vinyl fluoride monomer [C_2H_3F]. Typical applications for fluoropolymers are found in electrical/electronic uses and pipe and chemical processing equipment.

MELAMINE-FORMALDEHYDE

Thermosetting resins formed by the condensation reaction of formaldehyde [HCHO] and melamine [$C_3N_3(NH_2)_3$]. The chemistry is analogous to that of urea-formaldehyde except that the three amino groups of melamine provide more possibilities for cross-linking, are more highly reactive, and all six hydrogen atoms of melamine will react, forming the hexamethyl compound. Typical applications are found in bonding and adhesives, coatings, and consumer products.

Glossary

NITRILE RESINS

Thermoplastic resins composed of acrylonitrile [CH_2CHCN] along with comonomer such as acrylates, methacrylates, butadiene [$CH_2CHCHCH_2$] and styrene [$C_6H_5CHCH_2$]. Both straight copolymers and copolymers grafted onto elastomeric backbones are available. The unique property of these materials is outstanding resistance to passage of gases and water vapor, making them useful in packaging applications.

NYLON

A generic name for a family of long-chain polyamide engineering thermoplastics which have recurring amide groups [-CO-NH-] as an integral part of the main polymer chain. Nylons are synthesized from intermediates such as dicarboxylic acids, diamines, amino acids and lactams, and are identified by numbers denoting the number of carbon atoms in the polymer chain derived from specific constituents, those from the diamine being given first. The second number, if used, denotes the number of carbon atoms derived from a diacid. Commercial nylons are as follows: *nylon* 4 (polypyrrolidone)-a polymer of 2-pyrrolidone [$CH_2CH_2CH_2C(O)NH$]; *nylon* 6 (polycaprolactam)-made by the polycondensation of caprolactam[$CH_2(CH_2)_4NHCO$]; *nylon* 6/6-made by condensing hexamethylenediamine [$H_2N(CH_2)_6NH_2$] with adipic acid [$COOH(CH_2)_4COOH$]; *nylon* 6/10-made by condensing hexamethylenediamine with sebacic acid[$COOH(CH_2)_8COOH$]; *nylon* 6/12-made from hexamethylenediamine and a 12-carbon dibasic acid; *nylon* 11-produced by polycondensation of the monomer 11-amino-undecanoic acid [$NH_2CH_2(CH_2)_9COOH$]; *nylon* 12-made by the polymerization of laurolactam [$CH_2(CH_2)_{10}CO$]or cyclododecalactam, with 11 methylene units between the linking -NH-CO- groups in the polymer chain. Typical applications for nylons are found in automotive parts, electrical/electronic uses, and packaging.

PETROLEUM RESINS

Thermoplastic resins obtained from a variable mixture unsaturated monomers recovered as byproduct from cracked and distilled petroleum streams. They also contain indene [$C_6H_4CH_2CHCH$], which is copolymerized with a variety of other monomers including styrene [$C_6H_5CHCH_2$], vinyl toluene [$CH_2CHC_6H_4CH_3$], and methyl indene [$C_6H_4CH_3CH_2CHCH$]. Typical applications are found in adhesives, printing inks, rubber compounding, and surface coatings.

PHENOLIC

These thermosetting resins are credited with being the first commercialized wholly synthetic polymer or plastic. The basic raw materials are formaldehyde [HCHO] and phenol [C_6H_5OH], although almost any reactive phenol or aldehyde can be used. The phenols used commerically are phenol, cresols [$CH_3C_6H_4OH$], xylenols [$(CH_3)_2C_6H_3OH$], p-t-butylphenol [$C_4H_9C_6H_4OH$], p-phenylphenol [$C_6H_5C_6H_4OH$], bisphenols [$(C_6H_4OH)_2$], and resorcinol [$C_6H_4(OH)_2$]. The aldehydes used are formaldehyde and furfural [C_4H_3OCHO]. In the uncured and semi-cured condition, phenolic resins are used as adhesives, casting resins, potting compounds, and laminating resins. As molding powders, phenolic resins can found in electrical uses

POLYAMIDE-IMIDE

Engineering thermoplastic resins produced by the condensation reaction of trimellitic anhydride [$OCC_6H_3C_2O_3$] and various aromatic diamines. Typical applications are found in aerospace, automotive and heavy equipment industries.

POLYARYLATES

Engineering thermoplastic resins produced by interfacial polymerization of an aqueous solution of the disodium salt of bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$] with phthalic acid chlorides [$C_6H_4(CO)_2Cl_2$] in methylene chloride (CH_2Cl_2]. The major use of polyarylates is in outdoor lighting.

POLYBUTYLENE

Thermoplastic resins produce via stereospecific Ziegler-Natta polymerization of butene-1 monomer [$CH_3CHCH_2CH_3$]. Typical applications are found in pipe and packaging film.

POLYCARBONATE

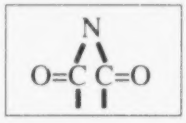
Engineering thermoplastic resins produced by (1) phosgenation of dihydric phenols, usually bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$], (2) ester exchange between diaryl carbonates and dihydric phenols, usually between diphenyl carbonate [$(C_6H_5O)_2CO$] and bisphenol A and (3) interfacial polycondensation of bisphenol A and phosgene [$COCl_2$]. Typical applications are found in glazing, appliances, and electrical uses.

POLYETHYLENE

A family of thermoplastic resins obtained by polymerizing the gas ethylene [C_2H_4]. Low molecular weight polymers of ethylene are fluids used as lubricants; medium weight polymers are waxes miscible with paraffin; and the high molecular weight polymers (i.e. over 6000) are the materials used in the plastics industry. Polymers with densities ranging from about .910 to .925 are called *low density*; those of densities from .926 to .940 are called *medium density*; and those from .941 to .965 and over are called *high density*. The low density types are polymerized at very high pressures and temperatures, and the high density types at relatively low temperatures and pressures. A relatively new type called linear low density polyethylene is manufactured through a variety of processes: gas phase, solution, slurry, or high pressure conversion. A high efficiency catalyst system aids in the polymerization of ethylene and allows for lower temperatures and pressures than those required in making conventional low density polyethylene. Copolymers of ethylene with vinyl acetate ethyl acrylate, and acrylic acid are commercially important. Major polyethylene applications can be found in packaging, housewares, toys and communications equipment.

POLYIMIDES

A family of thermoset and thermoplastic resins characterized by repeating imide linkages:



There are four types of aromatic polyimides: (1) condensation products made by the reaction pyromellitic dianhydride (PMDA) [$C_6H_2(C_2O_3)_2$] and aromatic diamines such as 4,4'-diaminodiphenyl ether [$(C_6H_4NH_2)_2O$]; (2) condensation products of 3,4,3',4'-benzophenone tetracarboxylic dianhydride (BTDA) [$(C_6H_3)_2CO(C_2O_3)_2$] and aromatic amines;(3) the reaction of BTDA and a diisocyanate such as 4,4'-methylene-bis(phenylisocyanate) [$OCNC_6H_4CH_2C_6H_4NCO$]; and, (4) a polyimide based on diaminophenylindane and a dicarboxylic andhydride such as carbonyldiphthalic anhydride [$OC_6H_4(CO)_2COC_6H_4(CO)_2$]. Thermoset polyimides are produced in condensation polymers that possess reactive terminal groups capable of subsequent cross-linking through an addition reaction. Typical applications for thermoplastic and thermosetting polyimides are transportation and electronics.

POLYPHENYLENE OXIDE, MODIFIED

Engineering thermoplastic resins produced by the oxidative coupling of 2, 6-dimethylphenol [$(CH_3)_2C_6H_3OH$] (xylenol), then blended with impact polystyrene. Typical applications are found in electrical/electronic uses, business machine parts, appliances, and automotive parts.

POLYPHENYLENE SULFIDE

Engineering thermoplastic resins produced by the reaction of p-dichlorobenzene [$C_6H_4Cl_2$] with sodium sulfide [Na_2S]. The major use for polyphenylene sulfide is in electrical/electronic parts and automotive parts.

POLYPROPYLENE

Thermoplastic resins made by polymerizing propylene [CH_3CHCH_2] and in the case of copolymers with monomers, with suitable catalysts, generally aluminum alkyl and titanium tetrachloride mixed with solvents. The monomer unit in polypropylene is asymmetric and can assume two regular geometric arrangements: isotactic, with all methyl groups aligned on the same side of the chain, or syndiotactic, with the methyl groups alternating. All other forms, where this positioning is random, are called atactic. Commerical polypropylene contains 90-97% crystalline or isotactic PP with the remainder being atactic. Most processes remove excess atactic PP. This by-product is used in adhesives, caulks, and cablefilling compounds. Major applications of commerical PP are found in packaging, automotive, appliance and carpeting markets.

POLYSTYRENE

High molecular weight thermoplastic resins produced generally by the free-radical polymerization of styrene monomer [$C_6H_5CHCH_2$] which can be initiated by heating alone but more effectively by heating in the presence of free-radical initiator (such as benzoyl peroxide [$(C_6H_5CO)_2O_2$]. Typical processing techniques are modified mass polymerization or solution polymerization, suspension polymerization, and expandable beads. Major markets for polystyrene are in consumer and institutional products, electrical/electronic uses, and building/construction.

POLYURETHANES

A large family of polymers based on the reaction product of an organic isocyanate with compounds containing a hydroxyl group. The commonly used isocyanates are toluene diisocyanate (TDI) [$CH_3C_6H_3(NCO)_2$], methylene diphenyl isocyanate (MDI) [$OCNC_6H_4CH_2C_6H_4NCO$], and polymeric isocyanates (PMDI), obtained by the phosgenation of polyamines derived from the condensation of aniline [$C_6H_5NH_2$] with formaldehyde (HCHO). Polyols (with hydroxyl groups) are macroglycols which are either polyester or polyether based. Polyurethane elastomers and resins take the form of liquid castings systems thermoplastic elastomers and resins, microcellular products, and millible gums. Typical applications are found in the automotive industry. Polyurethane foams are widely used in transportation, furniture, and construction markets.

Glossary

POLYVINYL ACETATE (PVAc) & OTHER VINYLS

Polyvinyl acetate is a thermoplastic resin produced by the polymerization of vinyl acetate monomer [$CH_3COOCHCH_2$] in water producing an emulsion with a solids content of 50-55%. Most polyvinyl acetate emulsions contain co-monomers such as n-butyl acrylate, 2-ethyl hexyl acrylate, ethylene, dibutyl maleate and dibutyl fumarate. Polymerization of vinyl acetate with ethylene also can be used to produce solid vinyl acetate/ethylene copolymers with more than 50% vinyl acetate content. Polyvinyl alcohol (PVOH) is produced by methanolysis or hydrolysis of polyvinyl acetates. The reaction can be controlled to produce any degree of replacement of acetate groups. Co-polymers of replaced acetate groupings and other monomers such as ethylene and acrylate esters are commercially important. *Polyvinyl butyral* (PVB) - made by reacting PVOH with butyraldehyde [$CH_3(CH_2)_2CHO$]. *Polyvinyl formal* - made by condensing formaldehyde [HCHO] in presence of PVOH or by the simultaneous hydrolysis and acetylization of PVAc. *Polyvinylidene chloride* - made by the polymerization of 1,1-dichloroethylene [CH_2CCl_2]. Typical applications for the above resins are found in adhesives, paints, coatings and finishes, and packaging.

POLYVINYL CHLORIDE

Thermoplastic resins produced by the polymerization of the gas vinyl chloride [CH_2CHCl]. Under pressure, vinyl chloride becomes liquified and is polymerized by one of four basic processes: suspension, emulsion, bulk, and solution polymerization. The pure polymer is hard, brittle and difficult to process, but it becomes flexible when plasticizers are added. A special class of PVC resin of fine particle size, often called dispersion grade resin, can be dispersed in liquid plasticizers to form plastisols. The addition of a volatile diluent or a solvent to the plastisol produces an organosol. Copolymers with vinyl acetate, vinylidene chloride, and maleate and fumarate esters find commercial application. Major markets for PVC are in building/construction, packaging, consumer and institutional products, and electrical/electronic uses.

STYRENE ACRYLONITRILE

Thermoplastic copolymers of styrene [$C_6H_5CHCH_2$] and acrylonitrile [CH_2CHCN]. SAN resins are random, amorphous copolymers produced by emulsion, suspension, or continuous mass polymerization. Typical uses include automobile instrument lenses and housewares.

STYRENE BUTADIENE LATEXES & OTHER STYRENE COPOLYMERS

Styrene butadiene latexes usually have a resin content of about 50%. The styrene/butadiene ratio varies from 54:46 to 80:20. Most are carboxylated by the use of such acids as maleic [$HOOCCHCHCOO$], fumaric [$HOOCCHCHCOOH$], acrylic [$CH_2CHCOOH$], or methacrylic [$CH_2C(CH_3)COOH$]. Two types of *styrene-maleic anhydride* (SMA) [$(COCH)_2O$] are available: SMA copolymers, with and without rubber impact modifier (e.g. DYLARK®) and SMA terpolymer alloys (e.g. CADON®). *K-Resin* ® is a solid styrenebutadiene copolymer resin. Acrylic monomers are also used in conjunction with styrene (or styrene plus other monomers) to produce specialty resins. For example, there are transparent terpolymers of methyl methacrylate, butadiene, and styrene (MBS), and others of acrylonitrile, an acrylic monomer, and styrene (AAS). Ion-exchange resins or divinylbenzene-modified polystyrene are another variation. SB latexes are used in carpet backing and paper coatings. The other styrenics are used in paints, coatings, and floor polishes, plus many other uses.

Glossary

SULFONE POLYMERS

A family of engineering thermoplastic resins characterized by the sulfone ([SO_2] group. *Polysulfone* is made by the reaction of the disodium salt of bisphenol A[$(CH_3)_2C(C_6H_4OH)_2$] with 4,4'-dichlorodiphenyl sulfone(4,4'-DCDPS [$(C_6H_4Cl)_2SO_2$]. *Polyethersulfone* is made by the reaction of 4,4'-DCDPS with potassium hydroxide [KOH]. *Polyphenylsulfone* is similar to the other sulfone polymers. Typical applications for sulfone polymers are found in electrical/electronic uses and automotive parts.

THERMOPLASTIC POLYESTER (SATURATED)

A family of polyesters in which the polyester backbones are saturated and hence unreactive. The most common commercial types are: PET (polyethylene terephthalate) produced by polycondensation of ethylene glycol [CH_2OHCH_2OH] with either dimethyl terephthalate (DMT) [$C_6H_4(COOCH_3)_2$] or terephtalic acid (TPA) [$C_6H_4(COOH_2$]; and PBT (polybutylene terephthalate) produced by the reation of DMT with 1,4 butanediol [$NO(CH_2)_4OH$]. Typical applications are found in packaging, automotive, electrical, and consumer markets.

UREA-FORMALDEHYDE

Formed by the condensation reaction of formaldehyde [HCHO] and urea [$CO(NH_2)_2$]. These thermoset resins are clear water-white syrups or white powered materials which can be dispersed in water to form colorless syrups. They cure at elevated temperatures with appropriate catalysts. Molding powders are made by adding fillers to the uncured syrups, forming a consistency suitable for compression and transfer molding. The liquid and dried resins find extensive used in laminates and chemically-resistant coatings. The molding compounds are formed into rigid electrical and decorative products.

UNSATURATED POLYESTER

Thermosetting resins made by the condensation reaction between difunctional acids and glycols. The resulting polymer is then dissolved in styrene [$C_6H_5CHCH_2$] or other vinyl unsaturated monomer. The structures of the acids and glycols used and their proportions, especially the ratio of the unsaturated versus the saturated acid, and the type and amount of monomer used, are all tailored for each resin to balance economy, processing characteristics, and performance properties. One common formulation is the reaction of maleic anhydride [$(COCH)_2O$], phthalic anhydride [$C_6H_4(CO)_2O$], and propylene glycol [$CH_2CHOHCH_3OH$]. Both dicyclopentadiene [$(C_5H5)_2$] and isophthalic acid [$C_6H_4(COOH)_2$] can be substituted for phthalic anhydride. Vinyl ester resins are linear reaction products of bisphenol A [$(CH_3)_2C(C_6H_4OH)_2$] and epichlorohydrin [CH_2OCHCH_2Cl] that are terminated with an unsaturated acid such as methacrylic acid [$CH_2C(CH_3)COOH$]. Typical applications are found in transportation, appliances, electrical, and construction markets.

Sources: *Chemical Economics Handbook, SRI International, Modern Plastics Encyclopedia*
Whittington's Dictionary, The Condensed Chemical Dictionary

DEFINITIONS OF SELECTED PLASTICS PROPERTIES

ABLATION - The degradation and decomposition of a material caused by high heat friction.

ABRASION RESISTANCE - Ability to resist surface wear.

AGING - The effect, on materials, of exposure to an environment for an interval of time.

ARC RESISTANCE - The total time in seconds that intermittent arc may play across a plastic surface with rendering the surface conductive.

BLEEDING - The diffusion of color out of a plastic part into surrounding surface of part.

BLOCKING - The adhesion between touching layers of plastic, such as that which may develop under pressure during storage or use.

BLOOM - A visible exudation or efflorescence on the surface of a plastic; bloom can be caused by lubricant, plasticizer, etc.

BRITTLE POINT - The highest temperature at which an elastomer fractures in a prescribed impact test procedure.

BRITTLE TEMPERATURE - The lowest temperature at which a plastic material withstands given conditions without failure.

BUCKLING - Crimping of the fibers in a composite material, often occurring in glass-reinforced thermosets due to resin shrinkage during cure.

BULK DENSITY - The density of a molding material in loose form (granular, nodular, etc.) expressed as a ratio of weight to volume.

BULK FACTOR - The ratio of the volume of a molding compound or powdered plastic to the volume of the solid piece produced from it.

COEFFICIENT OF EXPANSION - The fractional change in dimension of a material for a unit change in temperature.

COEFFICIENT OF FRICTION - A measure of the resistance to sliding of one surface in contact with another surface.

COEFFICIENT OF LINEAR EXPANSION - A measure of the change in dimension of an object caused by a change in temperature; specifically measured by the increase in length of an object per unit degree in temperature.

COEFFICIENT OF THERMAL EXPANSION - The change in volume per unit volume produced by a one degree rise in temperature.

COMPRESSIVE STRENGTH - The ability of a material to resist a force that tends to crush.

Glossary

CORROSION RESISTANCE - The ability of a material to withstand contact with ambient natural factors or those of a particular artificially created atmosphere.

CRACK - An actual separation of molded material, visible on opposite surfaces of the part, and extending through the thickness; a fracture.

CRAZING - Fine cracks which may extend in a network on or under the surface of a plastic material.

CREEP - The change in dimension of a plastic under load over a period of time, not including the initial instantaneous elastic deformation.

CROSS-LINKING - Applied to polymer molecules, the setting-up of chemical links between the molecular chains. When extensive, as in most thermosetting resins, cross-linking makes one infusible supermolecule of all the chains.

DEFLECTION TEMPERATURE UNDER LOAD - The temperature at which a simple beam has deflected a given amount under load (formerly called heat distortion temperature).

DEFORMATION - Any change of form or shape in a body; the linear change of dimension of a body in a given direction produced by the action of external forces.

DEGRADATION - A deleterious change in the chemical structure of a plastic.

DETERIORATION - A permanent change in the physical properties of a plastic evidenced by impairment of these properties.

DIMENSIONAL STABILITY - Ability of a plastic part to retain the precise shape to which it was molded, cast, or otherwise fabricated.

DISCOLORATION - Any change from an initial color possessed by a plastic; a lack of uniformity in color where color should be uniform over the whole area of a plastic object.

ELASTICITY - That property of plastics materials by virtue of which they tend to recover their original size and shape after deformation.

ELASTOMERIC - The property of a material which at room temperature can be stretched under low stress to at least twice its original length and, upon immediate release of the stress, will return with force to its approximate original length.

ELECTRICAL STRENGTH [DIELECTRIC STRENGTH] - That property of an insulating material which enables it to withstand electric stress; the highest electric stress which an insulating material can withstand for a specificed time without the occurrence of electrical breakdown by any path through its bulk.

ELONGATION - Deformation caused by stretch; the fractional increase in length of a material stressed in tension.

ENVIRONMENTAL STRESS CRACKING - The susceptibility of a thermoplastic resin to crack or craze when in the presence of surface active agents or other environments.

Glossary

EXTENSIBILITY - The ability of a material to extend or elongate upon application of sufficient force, expressed as a percent of the original length.

EXUDATION - The formation in liquid form a plasticizer on the surface of a plasticized resin.

FADING - Any lightening of an initial color possessed by a plastic; measured by accelerating the process by subjecting the plastic to high intensity ultraviolet rays of approximately the same wave length as those found in sunlight.

FATIGUE - The failure or decay of mechanical properties after repeated applications of stress.

FLAMMABILITY - Measure of the extent to which a material will support combustion.

FLEX LIFE - The time of heat-aging that an insulating material can withstand before failure when bent around a specific radius (used to evaluate thermal endurance).

FLEXURAL STRENGTH - The resistance of a material to being broken by bending stresses.

FLOW MARKS - Wavy surface appearance of an object molded from thermoplastic resins, caused by improper flow of the resin into the mold.

GEL POINT - The stage at which a liquid begins to exhibit pseudoelastic properties. Also known as "gel-time."

GLASS TRANSITION TEMPERATURE - The center of the temperature range in which a noncrystalline solid changes from being glass-brittle to being viscous.

GLOSS - Brightness or luster of a plastic resulting from a smooth surface.

HAZE - Cloudy appearance within, or on the surface, of a plastic.

HEAT DISTORTION POINT - The temperature at which a standard test bar deflects under a stated load.

HEAT RESISTANCE - The property or ability of plastics and elastomers to resist the deteriorating effects of elevated temperatures.

HYDROLYSIS - Chemical decomposition of a substance involving the addition of water.

HYDROPHILIC - Capable of absorbing water.

HYDROPHOBIC - Capable of repelling water.

HYGROSCOPIC - Capable of adsorbing and retaining atmospheric moisture.

IMPACT STRENGTH - The ability of a material to withstand shock loading.

LACK OF FILLOUT - An area, occurring usually at the edge of a laminated plastic, where the reinforcement has not been wetted with resin.

Glossary

MELT INDEX - The amount in grams, of a thermoplastic resin which can be forced through a 0.0825 inch orifice when subjected to 2160 grams force in 10 minutes.

MELTING POINT - The temperature at which a resin changes from a solid to a liquid.

MELT STRENGTH - The strength of a plastic while in the molten state.

MIGRATION - The transfer of a material from a plastic body to other contacting solids.

MOISTURE ABSORPTION - The pick-up of water vapor from air by a material. It relates only to vapor withdrawn from the air by a material and must be distinguished from water absorption, which is the gain in weight due to the take-up of water by immersion.

MOTTLE - The desired or accidental mixture of colors or shades of a color giving more or less distinct or complicated patterns or specks, spots, or streaks of color; any irregular imperfections on the surface.

NECKING - The localized reduction in cross-section which may occur in a material under tensile stress.

OPALESCENCE - The limited clarity of vision through a sheet of transparent plastic at any angle, because of diffusion within or on the surface of the plastic.

OPTICAL DISTORTION - Any apparent alteration of the geometric pattern of an object when seen through a plastic or as reflection from a plastic surface.

OXIDATION - The chemical reaction involving the process of combining with oxygen to form an oxide; the deterioration of an adhesive film due to atmospheric exposure; the break down of a hot melt adhesive due to prolonged heating and oxide formation.

PIT - Small regular or irregular crater in the surface of a plastic, usually with width approximately of the same order of magnitude as its depth.

PLASTICITY - A property of plastics which allows the material to be deformed continuously and permanently without rupture upon the application of a force that exceeds the yield value of the material. (The opposite of "elasticity.").

SHEARING - Breaking caused by the action of equal and opposed forces, located in the same plane.

SPECIFIC GRAVITY - The ratio of the weight of any volume of a substance to the weight of an equal volume of another substance taken as standard at a constant or stated temperature. Solids and liquids are usually compared.

SPECIFIC HEAT - The quantity of heat required to raise the temperature of a unit mass of a substance one (1) degree under specified conditions.

STRESS-CRACK- External or internal cracks in a plastic caused by tensile stresses less than that of its short-time mechanical strength.

SWEATING - Exudation of small drops of liquid, usually a plasticizer or softener, on the surface of a plastic part.

Glossary

SWELL - A dimensional increase caused by exposure to liquids and/or vapors.

TEAR RESISTANCE - The force required to tear completely across a notched specimen tested according to prescribed procedures, expressed in pounds per inch of specimen thickness.

TENSILE STRENGTH OR STRESS - The maximum tensile load per unit area of original cross section, within the gage boundaries, sustained by the specimen during a tension test.

THERMAL CONDUCTIVITY -Ability of a material to conduct heat.

THERMOELASTICITY - Rubber-like elasticity exhibited by a rigid plastic and resulting from an increase of temperature.

THERMOPLASTICITY - The ability of material to be deformed without breaking with a relatively fast flow, when (at a suitable temperature) this material is properly stressed.

TUNNELING - A condition occuring in incompletely bonded laminates, characterized by release of longitudinal portions of the substrate and deformation of these portions to form tunnel-like structures.

VISCOSITY- The property of resistance to flow exhibited within the body of a material, expressed in terms of relationship between applied shearing stress and resulting rate of strain in shear.

WEATHERING - The exposure of plastics outdoors.

Other Sources of Plastics Information

Other Sources Of Plastics Information

Business Consulting Groups and Publishers

Business Communications Co., Inc. - 25 Van Zant St., Norwalk, CT 06855 - 203/853-4266
Chem Systems Inc. - 303 S. Broadway, Tarrytown, NY 10591 - 914/631-2828
Chemical Data, Inc. - 2900 N. Loop West, Suite 830, Houston, TX 77092 - 713/683-3900
Eldib Engineering & Research, Inc. - 613 Springfield Ave., Berkeley Heights, NJ 07922 - 201/464-2244
Franklin Associates, Ltd. - 4121 W. 83rd Street, Prairie Village, KA 66208 - 913/649-2225
Frost & Sullivan, Inc. - 106 Fulton St., New York, NY 10038 - 212/233-1080
International Plastics Consultants Corp. - 1492 High Ridge Rd., Stamford, CT 06903 - 203/968-1233
Kline & Co., Inc. - 165 Passaic Ave., Fairfield, NJ 07006 - 201/227-6262
R.M. Kossoff & Associates, Inc. - 10 Rockefeller Plaza, New York, NY 10020 - 212/246-4035
Arthur D. Little, Inc. - 25 Acorn Park, Cambridge, MA 02140 - 617/864-5770
Margolis Marketing & Research Co. - 232 Madison Ave., Suite 905, New York, NY 10016 - 212/685-1278
Market Search, Inc. - 2727 Holland Sylvania Rd. Suite A, Toledo, OH 43615 - 419/535-7899
Mastio & Company - 11263 Wright St., Omaha, NE - 68144 - 402/334-4800
Morton Research Coporation - 28 Merrick Ave., Merrick, NY 11566 - 516/378-1066
Noyes Data Corp. - Mill Road at Grand Ave., Park Ridge,NJ 07656 - 201/391-8484
Peter Sherwood Associates, Inc. - 20 Harlem Ave., White Plains, NY 10603 - 914/761-3033
Phillip Townsend Associates - P.O. Box 90327, Houston, TX 77090 - 713/873-8733
Predicasts, Inc. - 11001 Cedar Ave., Cleveland, OH 44106 - 216/795-3000
Skeist Laboratories, Inc. - 375 Route 10, Whippany, NJ 07981 - 201/515-2020
Springborn Group - 20 Springborn Ctr., Enfield, CT 06082 - 203/749-8371
SRI International - 333 Ravenswood Ave., Menlo Park, CA 94025 - 415/326-6200
The Target Group - 1000 Harston Lane, Philadelphia, PA 19118 - 215/233-4083
Technomic Consultants, Inc. - 300 South Riverside Plaza, Chicago, IL 60606 - 312/876-0004
Technomic Publishing Co. - 851 New Holland Ave., Box 3535, Lancaster, PA 17604 - 717/291-5609

Government Publications

Annual Survey of Manufacturers - Bureau of the Census
Census of Manufacturers - Bureau of the Census
Current Industrial Reports - Bureau of the Census
Foreign Trade Reports - FT 135 (imports), FT 410 (exports) - Bureau of the Census
Guide to Census Bureau Data Files and Special Tabulations - Bureau of the Census
Guide to Foreign Trade Statistics - Bureau of the Census
Producer Price Indexes - Bureau of Labor Statistics
Standard Industrial Classification Manual - Office of Management and Budget
Statistical Abstract of the U.S. - Department of Commerce
Statistical Services of the U.S. Government - Office Management and Budget
Synthetic Organic Chemicals - International Trade Commission
U.S. Industrial Outlook - Department of Commerce

Newspapers

Chemical Marketing Reporter - 100 Church St., New York, NY 10007 - 212/732-9820
Journal of Commerce - 110 Wall St., New York, NY 10005 - 212/425-1616
Plastics News - 1725 Merrinan Rd., Suite 300, Akron, OH 44313 - 216/836-9180

Other Sources Of Plastics Information

Trade Associations & Professional Organizations

American Chemical Society - 1155 16th St., NW, Washington, D.C. 20036 - 202/872-4600
Chemical Manufacturers Assn. - 2501. M St., NW, Washington, D.C. 20037 - 202/887-1100
Chemical Marketing Research Assn. - 139 Chestnut Ave., Staten Island, NY 10305 - 718/727-0550
Chemical Specialities Manufacturers Assn. - 1001 Connecticut Ave., NW, Washington, D.C. 20036 - 202/223-8891
Composite Can & Tube Institute - 1818 N St., NW, Suite T-10, Washington, D.C. 20036 - 202/223-4840
Drug, Chemical & Allied Trades Assn. - 42-40 Bell Blvd., Suite 604, Bayside, NY 11361 - 718/229-8891
Dry Color Manufacturers Assn. - Sutie 202, 206 N. Washington St., P.O. Box 20839, Alexandria, VA 22314 - 703/684-4044
Flexible Packaging Assn. - Suite 500, 1090 Vermont Ave., NW, Washington, D.C. 20005 - 202/842-3880
INDA - 1700 Broadway, New York, NY 10019 - 212/582-8401
International Institute of Synethetic Rubber Producers - 2077 S. Gessner Rd., Suite 133, Houston, TX 77063 - 713/783-7511
International Isocyanate Institute - 119 Cherry Hill Rd., Parsipanny, NJ 07054 - 201/263-7517
National Paint & Coatings Assn. - 1500 Rhode Island Ave. NW, Washington, D.C. 20005 - 202/462-6272
Polyurethane Manufacturers Assn. - 1500 K St., NW, Washington, D.C. 20005 - 202/682-1338
Society of Plastics Engineers - 14 Fairfield Drive, Brookfield Center, CT 06805 - 203/775-0471
Society of the Plastics Industry-Canada - 1262 Don Mills Rd., Suite 104, Don Mills, Ontario M3B2W7 - 416/449-3444
Synthetic Organic Chemical Manufacturers Assn. - 1330 Connecticut Ave., NW, Suite 300, Washington, D.C. - 202/659-0060

Trade Publications

Canadian Plastics - 1450 Don Mills Road, Ontario M3B2X7 - 416/445-6641
Chemical Engineering - 1221 Ave. of the Americas, New York, NY 10020 - 212/512-3198
Chemical & Engineering News - 1155 16th St., NW, Washington, D.C. 20036 - 202/872-4600
Chemical Week - 1221 Ave. of the Americas, New York, NY 10020 - 212/586-3430
Material Engineering - 1100 Superior Ave., Cleveland, OH 44114 - 216/696-7000
Modern Plastics - 1221 Ave. of the Americas, New York, NY 10020 - 212/512-6243
Packaging Digest - 122 East 42nd St., New York, NY 10168 - 212/867-9191
Plastics Compounding - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Connection - P.O. Box 814, Amherst, MA 01004 - 413/549-5020
Plastics Design Forum - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Design & Processing - 17730 Peterson Rd., Libertyville, IL 60048 - 312/362-8711
Plastics Engineering - 14 Fairfield Drive, Brookfield Center, CT 06805 - 203/775-0471
Plastics Industry News - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Machinery & Equipment - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Packaging - 1129 East 17th Ave., Denver, CO 80218 - 303/832-1022
Plastics Technology - 633 Third Ave., New York, NY 10017 - 212/986-4800
Plastics World - 275 Washington St., Newton, MA 02158 - 617/964-3030

Other Sources Of Plastics Information

MONTHLY STATISTICAL REPORT

THERMOSETTING & THERMOPLASTIC RESINS

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MONTHLY STATISTICAL REPORT
THE SOCIETY OF PLASTICS INDUSTRY, INC.
(In thousands of pounds, dry weight basis)

THERMOSET RESINS

DECEMBER 1980

RESIN KIND & USE	SALES & CAPTIVE USE						PRODUCTION					
	DECEMBER			YEAR-TO-DATE			DECEMBER			YEAR-TO-DATE		
	1980	1979	% Change	1980	1979	% Change	1980	1979	% Change	1980	1979	% Change
EPOXY (UNMODIFIED) RESINS, TOTAL	30,709	25,639	+ 19.8	318,756R	331,970	-4.0	26,491	24,829	+ 6.7	315,039R	361,077	-12.8
Total Exports	3,732	3,496	+6.8	35,547	35,730	-0.5						
Total Domestic	26,977	22,143	+12.8	283,209R	296,240	-4.4						
Bonding & Adhesives	1,931	1,431	+34.9	17,742R	17,454	+1.7						
Flooring, Paving & Exposed Aggregate	1,886	1,481	+27.3	19,231R	19,583	-1.8						
Protective Coatings	13,417	9,648	+39.1	137,308R	146,137	-6.0						
Fiber Reinforced Laminates & Composites	5,164	4,785	+7.9	62,690R	60,268	+4.0						
Tooling, Casting & Molding Resins	2,749	2,417	+13.7	25,664R	30,940	-17.1						
All Other Uses	1,830	2,381	-23.1	20,574R	21,858	-5.9						
POLYESTER (UNSATURATED) RESINS, TOTAL	75,749	76,020	-0.4	921,169R	1,151,581	-20.0	76,524	78,733	-2.8	925,947R	1,147,174	-19.3
General Purpose Resins							66,503	68,719	-3.2	805,583R	1,010,750	-20.3
Fire Retardant Resins							2,757	2,550	+8.1	28,739	32,035	-10.3
Chemical Resistant Resins							7,264	7,464	-2.7	91,625 R	104,389	-12.2
Isophthalic Resins							3,830	4,917	-22.1	52,437R	63,158	-17.0
All Other Resins	903	841	+7.4	11,254	14,250	-22.5	3,434	2,547	+34.8	39,188R	41,231	-5.0
Total Exports	74,846	75,179	-0.4	909,915R	1,137,061	-20.0						
Total Domestic	59,069	58,428	+1.1	709,229R	905,949	-21.7						
Reinforced Plastics, Total	15,777	16,751	-5.8	200,686R	231,112	-13.2						
Non-Reinforced Plastics, Total	719,992	666,312	+8.1	7,467,465R	7,814,845	-4.4						
LOW-DENSITY POLYETHYLENE 0.940 & BELOW, TOTAL	109,576	65,000	+68.6	1,147,442R	897,575	+27.8	675,113	650,391	+3.8	7,290,727R	7,793,233	-6.4
Total Exports	610,416	65,000	+68.6	1,147,442R	897,575	+27.8						
Total Domestic	610,416	601,312	+1.5	6,320,023R	6,917,270	-8.6						
Film (12 Mils & Below)	392,242	383,360	+2.3	4,003749	4,363,250	-8.2						
Sheet (Over 12 Mils)	921	1,930	-52.3	18,176	25,825	-29.6						
Injection Molding	46,555	57,100	-18.5	519,294R	649,975	-20.1						
Wire & Cable	20,042	34,572	-42.0	335,403	424,139	-20.9						
Extrusion Coating	44,772	41,001	+9.2	517,406R	539,098	-4.0						
Blow Molding	5,129	4,786	+7.2	65,453R	59,524	+10.0						
Pipe & Conduit	2,660	2,293	+16.0	21,768R	32,718	-33.5						
Other Extruded Products	4,244	5,140	-17.4	56,018R	79,614	-29.6						
All Other Uses	93,851	71,130	+31.9	782,756R	743,127	+5.3						
HIGH-DENSITY POLYETHYLENE ABOVE 0.940, TOTAL	413,377	394,243	+4.9	4,393,038R	4,893,243	-10.2						
Total Exports	61,114	54,188	+12.8	526,438R	608,654	-13.5	407,174	419,864	-3.0	4,405,021	5,009,839	-12.1
Total Domestic	352,263	340,055	+3.8	3,866,600	4,284,589	-9.8						
Film (12 Mils & bBelow)	21,622	14,714	+46.9	201,086	212,399	-5.3						
Sheet (Over 12 Mils)	7,921	4,541	+74.4	54,937	65,520	-16.2						
Injection Molding	89,601	84,541	+6.0	937,964	1,073,724	-12.6						
Wire & Cable	6,285	7,074	-11.2	105,555	125,921	-16.2						
Extrusion Coating	3,213	2,038	+57.7	27,565	30,242	-8.9						
Blow Molding	138,168	139,521	-1.0	1,573,140	1,724,076	-8.8						
Pipe & conduit	30,468	25,135	+21.2	368,352	400,395	-8.0						
Other Extruded Products	1,703	2,120	-19.7	24,250	18,931	+28.1						
All Other Uses	53,282	60,371	-11.7	573,751	633,381	-9.4						

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